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SHIPBUILDING INDUSTRY &  
MARITIME ADMINISTRATION  
SHIP PRODUCIBILITY PROGRAM

TASK S-4  
ADVANCED PIPE TECHNOLOGY  
PROGRESS REPORT

**Newport News Shipbuilding**

A Tenneco Company Newport News, Virginia 23607



**Transportation**

Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE <b>29 APR 1976</b>		2. REPORT TYPE <b>N/A</b>		3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>Shipbuilding Industry &amp; Maritime A. Dminzstration Ship Producibility Program Task S-4 Advanced Pipe Technology Progress Report</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192 Room 128-9500 MacArthur Blvd Bethesda, MD 20817-5700</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>SAR</b>	18. NUMBER OF PAGES <b>172</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

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MARITIME ADMINISTRATION  
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TASK S-4  
ADVANCED - PIPE TECHNOLOGY  
PROGRESS REPORT  
to the  
ADVISORY COUNCIL MEETING  
THURSDAY, APRIL 29, 1976

Transportation  
Research Institute

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# TABLE OF CONTENTS

SECTION NO.	TITLE	PAGE NO.
	INTRODUCTION	1.
SECTION 1	OBJECTIVE AND SCOPE OF TASK	3
SECTION 2	METHOD OF TASK DEVELOPMENT	4
SECTION 3	TASK STUDY AREAS	11
APPENDIX A	NEWPORT NEWS SHIPBUILDING - -AND - DRY DOCK COMPANY PROPOSAL TO ACCOMPLISH TASK S-4, ADVANCED PIPE TECHNOLOGY, FOR BATH IRON WORKS CORPORATION (NOVEMBER 1974)	A-1
APPENDIX B	REVIEW OF REGULATORY BODY REQUIREMENTS DOCUMENTATION	B-1
APPENDIX C	REVIEW OF STATE-OF-THE-ART - PIPE TECHNOLOGY - LITERATURE SURVEY DOCUMENTATION	C-1
APPENDIX D	FACILITY SURVEY DOCUMENTATION (DOMESTIC)	D-1
APPENDIX E	PROPOSED FACILITY SURVEYS (FOREIGN) BACKGROUND INFORMATION AND <b>RATIONALE</b> FOR MAKING ON-SITE SURVEYS	E-1

## INTRODUCTION

The purpose of this Task S-4 Advanced Pipe Technology Progress Report can be stated as follows:

1. to present the basic objectives and scope of the task;
2. to describe the method of task development; and
3. to report on the status of task study areas.

This Progress Report is intended to cover the entire period from the signing of the Subcontract Agreement between Bath Iron Works Corporation and Newport News Shipbuilding on May 2, 1975 to April 1, 1976. Every effort was made to keep data contained in this report current to April 1, 1976. All data contained in the Task S-4 Advanced Pipe Technology Progress Report, dated November 22, 1975, has been completely reviewed, rewritten, updated as necessary, and included in this Progress Report along with new material which has been collected since November 22, 1975. The suggestions and comments recorded in the Minutes to the Advisory Council Meeting of November 22, 1975 have also been incorporated into this report. It should be noted that the project is tentatively scheduled for completion on September 30, 1976, so that any further input by contributors should be submitted no later than August 27, 1976.

For the purposes of consistency and continuity of presentation, the format of this Progress Report is numerically-keyed to both that of the Progress Report, dated November 22, 1975, and that of the Newport-News Shipbuilding Proposal to Accomplish Task S-4 Advanced Pipe Technology for Bath Iron Works Corporation (November 1974). A copy of the Proposal is contained in Appendix A. See Note below.

Throughout this report, references are made to numbered subsections in the Final Report (First Draft) for more detailed information concerning the various design, fabrication, and installation methods studied. This has been done to eliminate unnecessary duplication of information.

#### NOTE

One or two sets of subsection or paragraph numbers in parentheses follows each of the subsection or paragraph numbers and titles in this report. The first set refers to written matter on the same subject in the Advisory Council Progress Report, dated November 22, 1975; the second set (separated by a semicolon from the first set) refers to written matter on the same subject in the Newport News Shipbuilding Proposal to Accomplish Task S-4 Advanced Pipe Technology for Bath Iron Works Corporation, dated November 1974. An omission of either set indicates that no written matter on the same subject is given in the applicable document.

This method of numerical k-eying was adapted so that the history of any subject could be traced, and so that proper disposition could be made of all data collected during the course-of task development.

## SECTION 1 OBJECTIVE AND SCOPE OF TASK

### 1.1 OBJECTIVE (1.1; 1.1)

The primary objective of Task S-4 is to identify, evaluate, and document the most cost-effective state-of-the-art methods of designing, fabricating, and installing commercial ship piping systems. Documentation of Task S-4 consists of two Progress Reports, a Final Report, and a Backup Data Report. The two Progress Reports serve the purpose of providing the medium by which task progress is reported and by which the project is redirected to achieve maximum results. The Final Report provides overall documentation of task findings and will be made generally available to the U. S. shipbuilding industry by the Maritime Administration. The Backup Data Report will provide useful reference data collected during task development and will be made available to interested parties by the Maritime Administration only upon specific request.

### 1.2 SCOPE (1.2; 1.2)

The entire task is being developed within the scope of existing regulatory body requirements. However, recommendations to change existing requirements will be made in the Final Report if such changes would be necessary to allow the use of proven cost-effective methods of producing piping systems. In cases where further research and development would be required to "prove" a method, recommendations will be made accordingly. It is not within the scope of Task S-4 to research and develop new methods.

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## SECTION 2 METHOD OF TASK DEVELOPMENT

### 2.1 REVIEW OF EXISTING REGULATORY BODY REQUIREMENTS (2.1; 2.1)

In order to establish the overall limits of investigation at the outset of task development, we conducted an in-depth review of all existing regulations applicable to commercial ship piping systems. In particular, during this process we attempted to identify those areas where some degree of flexibility was allowed, such as in the selection of materials for a particular application. Our objective was to conduct our studies as closely within the bounds of existing regulations as possible.

During the course of Task S-4 development representatives of U. S. shipyards and design agents were asked to make comments relative to the format and content of existing regulatory body requirements. The essence of these comments, along with those of the Task S-4 project team, are documented in Appendix B of this report.

### 2.2 REVIEW OF STATE-OF-THE-ART PIPE TECHNOLOGY (2.2; 2.2)

#### 2.2.1 GENERAL (2.2.1; 2.2)

A review of the state-of-the-art pipe technology is presently being conducted by the Task S-4 project team. This review includes the following:

##### Literature Searches

##### Facility Surveys - Domestic

- Shipyards

- Design Agents -

- Piping Fabricators

- Piping Fabrication Equipmentk Vendors

- Research Facilities

##### Facility Surveys - Foreign

- Shipyards

- Piping Fabrication Equipmenti Vendors



### 2.2.2 LITERATURE SEARCHES (2.2.2; 2.2)

Several literature searches were conducted to collect information related to piping technology. Information was collected from the trade periodicals (listed in Appendix C, Section C1), various research papers and reports, and vendors' data. For convenience, all information collected was grouped into three categories, which are described in the following paragraphs.

CATEGORY I - Category I information describes specific cost-effective methods related to piping design, fabrication, or installation. Significant publications collected under this category are listed in Appendix C, Section C.2.

Although the scope of our literature search was relatively broad (considering the rather limited time frame available) we were somewhat disappointed in the small amount of information collected under Category I. It is probable that the scarcity of information related to piping technology is due to the preoccupation most domestic shipyards and many foreign shipyards have had in trying to improve the basic hull production process during the past several years. However, the increasing frequency over the past two years of articles specifically related to piping technology seems to indicate a trend toward more research in this area.

CATEGORY II - Category II information describes domestic or foreign facilities known to be advanced in piping technology. Significant publications collected under this category are listed in Appendix C, Section C.3.

The information collected under Category II was used to identify those facilities around the world which appear to be making significant progress in cutting costs in piping design, fabrication, or installation. This information was less detailed than that in Category I, but it did serve to help us establish the scope of our on-site domestic and foreign facility surveys.

CATEGORY III - Category III information describes vendor equipment and components which represent the present state-of-the-art. Significant publications collected under this category are listed in Appendix C, Section C.4.

Much information was collected under Category III, from both domestic and foreign sources. The form of this information ranges from commercial brochures to sample sets of drawings describing complete piping design and fabrication systems.

#### 2.2.3 DOMESTIC FACILITY SURVEYS (2.2.3, 2.2.4, 2-2.6: 2.2)

SHIPYARDS - Appendix D lists those major domestic shipyards which were selected for the purpose of collecting detailed information related to Task S-4 development. This selection was based both on the Category II information collected during our literature search and on personal contacts with representatives from the various shipyards. We were very much pleased with the cooperation from all shipyards contacted in arranging discussion sessions with cognizant personnel and in providing guided tours of their facilities. The success of Task S-4 depends heavily upon such cooperation.

The Task S-4 project team made on-site surveys of all thirteen of the shipyards listed in Appendix D. An in-house survey was conducted to determine what methods are presently being used at Newport News Shipbuilding to design, fabricate, and install piping systems. During all thirteen surveys an attempt was made to identify any methods which appeared to be particularly cost-effective.

For each shipyard surveyed, including Newport News Shipbuilding, we prepared a simplified description which was intended to capture the essence of the overall piping process at the shipyard. An attempt was made to update all descriptions so that they would be current to April 1, 1976. These descriptions are contained in Appendix D, Sections D.1 through D.13, and, for convenience, are grouped geographically into East Coast, Gulf Coast, and West Coast shipyards.

DESIGN AGENTS - In response to recommendations made at the Advisory Council Meeting on November 22, 1975, we conducted on-site interviews with representatives of four major U. S. design agents. Once again, we were well pleased with the cooperation and hospitality afforded us during these interviews. Although our primary objective was to secure information related to piping design, we were also able to gain some insight into the nature of relationships among the design agent, the owner, the shipbuilder, and the regulatory bodies.

For each of the four design agents surveyed, we prepared a summary of the survey discussion. These summaries are included in Appendix D, Sections D.14 through D.17. Comments relative to regulatory body requirements are also included in Appendix B.

PIPE FABRICATORS - On-site surveys of two facilities specializing in pipe fabrication were also conducted. One facility (on the East Coast) is utilizing a special patented hot bending process which produces bends of exceptional quality in large size pipe. A description of the basic process is provided in Appendix D, Section D.18. Another facility (on the West Coast) specializes in the fabrication of cryogenic piping.. A description of the methods and equipment utilized for this purpose is given in Appendix D, Section D.19.

PIPING FABRICATION EQUIPMENT VENDORS -In order to determine the present and near-future state-of-the-art in U. S. built pipe processing equipment, the Task S-4 project team conducted on-site surveys of two major vendors in this field. Descriptions of these surveys are provided in Appendix D, Sections D.20 and D.21.

RESEARCH FACILITIES - An on-site survey of one - research facility presently involved in advanced piping technology research was also conducted. A description of survey findings is given in Appendix D, Section D.22.

#### 2.2.4 FOREIGN FACILITY SURVEYS (2.2.5, 2.2.6: 2.2)

SHIPYARDS - Foreign shipyard surveys have thus far been limited to that which could be made from the Category II information collected during our literature searches. However, we are hopeful that MarAd will approve our proposal to make on-site surveys of four European shipyards in May or June. These four shipyards are known to utilize some of the most advanced outfitting methods and equipment in the world. Background information and rationale for making on-site surveys are contained in our proposal to MarAd; which is included in Appendix E, Sections E.1 through E.4.

PIPING FABRICATION EQUIPMENT VENDORS - Foreign vendor surveys have thus far been limited to commercial literature provided by the vendors. Four major vendors are marketing advanced piping processing equipment on a worldwide basis.

The names of these vendors and a listing of the types of systems and equipment they are marketing are provided in Appendix E, Section E.5. Since some of this equipment is in use at the four foreign shipyards selected for making on-site surveys, the Task S-4 project team hopes to provide detailed descriptions of operation of this equipment in the Final Report. In the absence of first-hand observation of equipment operation, however, a description of systems and equipment will be written from available literature and included in the Final Report.

## 2.3 PREPARATION OF METHOD DESCRIPTIONS AND DATA (2.3; 2.3)

### 2.3.1 IDENTIFICATION OF POTENTIAL COST-EFFECTIVE METHODS (2.3.1; 2.3)

During the course of task development we identified several methods related to the overall piping process which appear to be potentially cost-effective under specified conditions. It is anticipated that some form of cost-analysis will therefore be made for these methods and included in the Final Report. Those methods selected are noted under the appropriate heading in Section 3 of this report.

### 2.3.2 PREPARATION OF DETAILED METHOD DESCRIPTIONS AND DATA (2.3.2; 2.3)

Those methods identified under paragraph 2.3.1 will be studied in detail and all information necessary to accomplish a realistic cost-analysis will be collected and organized in standard format. Information will be included in the Final Report for those methods which are shown by our cost-analysis to be cost-effective.

## 2.4 COST-EVALUATION OF METHODS (2.4; 2.4)

After all information on specific methods has been collected, a cost-evaluation will be performed. This cost-evaluation will be made using a well-defined overall piping process as a reference baseline.

## 2.5 IDENTIFICATION OF AREAS FOR FUTURE STUDY (2.5; 2.5)

During the course of task development we identified areas of potential cost reduction which would require extensive research and development to investigate thoroughly and therefore were outside the scope of task S-4. Specific recommendations as to the nature of any future studies are included under the appropriate heading in Section 3 of this report.

## 2.6 ADVISORY COUNCIL PRESENTATIONS (2-6; 2.6)

The suggestions and comments read at the Advisory Council Meeting on November 22, 1975 were reviewed and the project was re-directed as necessary to achieve maximum results. It is anticipated that suggestions and comments made at this meeting will help the Task S-4 project team to finalize the form and content of the task end products.

## 2.7 PREPARATION OF END PRODUCTS (2.7: 2.7)

### 2.7.1 BACKUP DATA REPORT

A backup data report will be prepared which will contain useful reference data on items covered in the Final Report.

### 2.7.2 FINAL REPORT (2.7.2; 2.7)

A Final Report will be prepared which will present **indings of the overall task effort.**

### SECTION 3 TASK STUDY AREAS

#### 3.1        INTRODUCTION    (3-1:    3.1)

This section briefly describes the status of each of the task study areas presented at the Advisory Council Meeting on November 22, 1975. Specific references are made to numbered paragraphs in the Final Report (First Draft) for the task findings in these areas. This referencing technique was adopted to eliminate unnecessary duplication of task findings and to focus attention on the proposed format and content of the Final Report. ---

#### 3-.2    PROPOSED DESIGN STUDY AREAS    (3-2;    3.2

##### 3.2..1    NON-COMPUTERIZED "QUICK"" PIPE CALCULATIONS FOR-IN-HOUS USE    (3.2.1;    3.2.1)

Status:    Some data relative to the format and documentation pipe calculations was collected in this area.

Reference:    See Subsection 2.5 - PIPING SYSTEM CALCULATIONS in the Final Report (First Draft).

##### 3.2.2    COMPUTERIZED PIPE CALCULATIONS (3.2.2; 3.2.2)

Status:    Development of this item in detail was considered outside the funding limitations of Task S-4. However, NSRDC is actively involved in the development of integrated and stand-alone computer approaches to piping design for both Navy and commercial applications. The scope of their work covers the entire piping design process. Portions of their work are included in the Final Report (First Draft).

Reference:    See Subsection 2.5 - PIPING SYSTEM CALCULATIONS in the Final Report (First Draft).

### 3.2.3. COMPUTERIZED PIPE DETAILING (3.2.3; 3.2.3)

Status: The Maritime Administration has not yet funded Newport News Shipbuilding to complete the research and development phase of a computerized pipe detailing system. However, the results of the feasibility study are summarized in the Final Report (First Draft). Also included is a summary of the Electric Boat Match Marking System.

Reference: :See Subsection 2.11 - PIPING SYSTEM DETAIL. DRAWINGS in the Final Report (First Draft)

### 3.2.4 PIPE SUBASS-LIES (3.2:4; 3.2.4)

This item is covered under paragraph 3.4.4

### 3.2.5 DRAFTING TECHNIQUES (3.2.5; 3.2.5)

Status: Much of the project effort to date in the design area has been directed at reducing the time required to manually produce piping composite and arrangement drawings. Several novel methods have been observed and documented which appear to be cost-effective under given conditions. These methods include the use of Autokon to print out structural backgrounds for composite and arrangement drawings, the use of composite worksheets, the use of sepia reproducible of composites to produce individual arrangement drawings, and the use of isometric arrangement drawings. A description of these is provided in the Final Report. It is anticipated that a detailed analysis and cost-evaluation be performed on these methods and the results also documented in the Final Report (First Draft).

Reference: See Subsection 2.8 - INTERFERENCe CONTROL and Subsection .2.9 - PIPING SYSTEM ARRANGEMENT DRAWINGS in the Final Report (First Draft)

### 3.2.6 PIPE .MATERIALS (3.2.6; 3.2.6)

Status,: This item was deleted in accordance with the recommendations made at the Advisory Council Meeting of November 22, 1975. However, some data was collected in this area and is included in the Finai Report (First Draft).

Reference: See Subsection 2.7.MATERIAL PROCUREMENT AND CONTROL in the Final Report (First Draft;



### 3.2.7      REDUCTION OF NUMBER OF PIPE SIZES (3.2.7; 3.2.7)

Status: Most shipyards surveyed to date have reduced the number of pipe sizes used to some extent. Our task studies indicate that there are cost savings to be realized in this area. A summary of findings is given in the Final Report (First Draft),

Reference: See Subsection 2.7 - MATERIAL PROCUREMENT AND CONTROL in the Final Report (First Draft).

3.2.8 PIPE BENDS (3.2.8; 3.2.8)

status : Of all the shipyards surveyed to date, only two use 2D bends extensively. This item appears to offer significant savings over the use of fittings. A summary of findings in this area is included in the Final Report (First Draft).

Reference: See Subsection 3.5 - PIPE BENDING in the Final Report (First Draft).

3.2.9 SPECIAL PIPE FITTINGS (3.2.9; 3.2.9)  
This item is covered under paragraph 3.3.5.

3.2.10 NEAT PIPE DETAILS (3.2.10; not in Proposal)

Status: Discussions with design and fabrication personnel from the various shipyards surveyed to date indicate a wide range of practice regarding the use of template pipe details, from a low of 10 percent in one shipyard to a high of 30 percent in another. Since the degree of success enjoyed with a neat cut has a significant impact on installation costs, a study was made to determine the various factors involved. The results of this study are included in the Final Report.

Reference: See Subsection 2.11 - PIPING SYSTEM DETAIL DRAWINGS in the Final Report (First Draft).

3.2.11 PROBLEM AREAS IDENTIFIED (3.2.11; not in Proposal)

Prior to the Advisory Council Meeting on November 22, 1975, a number of significant problem areas were identified relative to piping design. These were discussed at the meeting and recommendations were made by the Advisory Council. Based on these recommendations, new task study areas were defined and data was collected as noted below.

U. S. COAST GUARD

Status: Several shipyards have indicated that delays in obtaining plan approvals have caused corresponding delays in their construction schedules. Also noted was the present format of rules which is difficult to follow. Representatives of several shipyards and design agents were asked to make comments relative to the whole subject of regulatory body problems. A summary of these comments was made and included in Appendix B of this report and also in the Final Report. (First Draft)

Reference: See Subsection 2.4 - REGULATORY BODY REQUIREMENTS in the Final Report (First Draft)

## DESIGN AGENTS

Status: Two shipyards noted the difficulty of building a ship to drawings prepared by design agents. Lack of communication with the design agent and unfamiliarity with the early stages of design were cited as the reasons.

Four design agents were surveyed. Survey documentation is provided in Appendix D, Section D.14 through D.17, and a summary of findings is included in the Final Report (First Draft).

Reference: See Subsection 2.3 - DESIGN AGENTS in the Final Report (First Draft).

## MATERIAL AVAILABILITY AND DOCUMENTATION

Status: All shipyards surveyed to date expressed concern over the growing problem of delivery delays of vendor-supplied items. Another problem is lack of a simple and consistent means of documenting piping components to allow for variations in design of a component supplied by several vendors. Also noted at two West Coast shipyards was the extremely poor quality of valves received by local suppliers.

A general study of this area was made and a summary of findings was included in the Final Report (First Draft).

Reference: See Subsection 2.-7 - MATERIAL PROCUREMENT AND CONTROL in the Final Report (First Draft)

### 3.3 PIPE FABRICATION STUDY AREAS (3.3; 3.3)

#### 3.3.1 PIPE SHOP LAYOUT AND THE PIPING FABRICATION PROCESS (3.3.1: 3.3.1)

Status: Although the fabrication of pipe in an efficient manner depends to some extent on shop layout, existing shop facilities at most shipyards surveyed to date are of necessity organized to suit local renditions rather than optimal flow paths. In most cases it would be difficult and expensive to reorganize to suit an optimal layout. In general, flow paths were observed to be straight-line and no significant areas of improvement seemed feasible which would be economically justifiable. It should be noted, however., that the addition of automated or semi-automated equipment for material handling, pipe cut-off, flange welding, etc. would require extensive rearrangement of equipment in all of the shops visited to date.

Based on. recommendations made at the Advisory Council

layouts would not be as useful as a piping fabrication process chart. Such a chart was therefore prepared and included in the Final Report (First Draft).

Reference: See Subsection 3.2 - PIPING FABRICATION PROCESS in the Final Report (First Draft).

- 3.3.2 PIPE BENDING (3.3.2; 3.3.2)

Status: Our original proposal addressed only "AUTOMATIC PIPE BENDING". However, our studies touched on all aspects of "PIPE BENDING". No domestic shipyard surveyed was found to have equipment for automatic pipe bending. Newport News Shipbuilding is a pioneer in the use of computerized pipe bending data and 2D booster bending machines, but does not have the capability of automatic bending. Many foreign Shipyards are known to be using such-equipment.

The Task S-4 project team collected much data on various pipe bending techniques and available equipment. A summary of findings is included in the Final Report (First Draft) .

Reference: See subsection 3.5 - PIPE BENDING in the Final Report (First Draft).

3.3.3 PIPE WELDING (3.3.3; 3.3.3)

Status: Our original proposal addressed only "AUTOMATIC PIPE WELDING". However, our studies touched on-all aspects of "PIPE WELDING". A summary of findings is included in the Final Report (First Draft).

Reference: See Subsection 3.6 - PIPE JOINING in the Final Report (First Draft).

3.3.4 PIPE CUTTING (3.3.4; not in Proposal)

Status: - several shipyards are using plasma burning equipment to cut saddle openings, miters, and branch openings in stainless steel and non-ferrous pipe. In particular, the process is used on LNG cargo piping. Other techniques for pipe cutting were also observed. A summary of findings is included in the Final Report (First Draft).

Reference: See Subsection 3.4 PIPE CUTTING AND END PREPARATION in the Final Report First Draft)

### 3.3.5 SPECIAL PIPE FITTINGS AND JOINING TECHNIQUES (3.3.5; not in Proposal)

This area includes items originally included under paragraph 3.2.9 and other items encountered which relate to the use of special techniques to eliminate fittings. The more significant findings are:

#### SWAGED PIPE CONNECTIONS

Status: Two shipyards surveyed are using swaged expanded pipe joints in lieu of couplings for copper and copper-nickel piping. The advantages of this technique are the reduction of the number of fittings required to join pipe, and the elimination of pipe joints. Mixed opinions were expressed concerning the overall advantages of this technique. Opposition was based upon doubts concerning "the ability to consistently form good swaged ends. A summary of findings is included in the Final Report (First Draft).

Reference: See Subsection 3.6 PIPE JOINING in the Final Report (First Draft).

#### EXTRUDED BOSSES

Status: Several shipyards have equipment for extruding bosses in copper and copper-nickel pipe. This process is relatively simple to perform and provides a satisfactory boss. A summary of findings is included in the Final Report (First Draft).

Reference: See Subsection 3.6 - PIPE JOINING in the Final Report (First Draft).

#### STEEL PIPE FLANGES

Status: One shipyard is using a process which is saving material costs. The process enables them to use steel in lieu of bronze flanges on copper-nickel pipe. The steel flange is machined to provide a recess on the inner face and the recess is then overlayed using a monel electrode to provide a suitable control surface at the flange face. Another shipyard has used this techniaue successfully for some Navy applicatlons. A summary of findings is included in the Fina Report (First Draft).

Reference: See Subsection 3.6 - PIPE JOINING in the Final Report (First Draft).

### 3.3.6 PIPE CLEANING (3.3.6; not in Proposal)

Status: Various techniques were observed for cleaning pipe after bending/fabrication. A summary of findings is included in the Final Report (First Draft).

Reference: See Subsection 3.7 - PIPE CLEANING in the Final Report (First Draft).

### 3.3.7 MISCELLANEOUS STUDY AREAS (3.3.7; not in Proposal)

#### GASKET FABRICATION

Status: Several shipyards-make their own gaskets (other than high-pressure and flexitalic gaskets ). Two shipyards have very impressive shop set-ups for: forming and storing. gaskets. Gaskets are punched from die-s on a hydraulic press. The quality is good and the cost minimal since gaskets are made by regular pipe shop workers during slack periods. A summary of findings is included in the Final Report (First Draft) .

Reference: See Subsection 3.8 - ALLIED PROCESSES in the Final Report (First Draft).

#### GAGE TUBING

status : The use of plastic-coated tubing for gage. tubing was observed on tanker work. This tubing can be coated singularly or in bundles of up to 24 tubes depending upon the size required. This tubing is sold in coils and the plastic coating is sufficiently strong to stand normal shipyard abuse. A summary of findings is included in the Final Report (First Draft).

Reference: See Subsection 2.7 - MATERIAL PROCUREMENT AND CONTROL in the Final Report (First Draft).

### 3.3.8 PROBLEM AREAS IDENTIFIED

Prior-to the Advisory Council Meeting on November 22, 1975 a number of significant problem areas were identified relative to pipe fabrication. These were discussed at t meeting and recommendations were made by the Advisory Council. Based on these recommendations, new task-study areas wei defined and data was collected as noted below.

## GALVANIZED PIPE

Status: The use of galvanized pipe is a problem area common to all shipyards surveyed. Alternatives presently available are discussed in the Final Report (First Draft).

Reference: See Subsection 2.7 - MATERIAL PROCUREMENT AND CONTROL in the Final Report (First Draft).

## PIPE END PREPARATION

Status: An improved method of end preparation is needed. Most shipyards are hand burning and grinding bevels. Another process observed was machine burning. One shipyard has ordered an H&M pipe lathe. Observations in various pipe shops indicate a need for economical equipment to replace hand burning and grinding of bevels. Present methods are discussed in the Final Report (First Draft).

Reference: See Subsection 3.4 - PIPE CUTTING AND PREPARATION in the Final Report (First Draft).

### 3.4 PIPE INSTALLATION STUDY AREAS (3.4; 3.4)

#### 3.4.1 MATERIALS HANDLING (3.4.-1; 3.4.1)

Status: Most shipyards surveyed use conventional pipe skids and pallets with shipway cranes. One shipyard is successfully using a special cradle pallet of their own design. One shipyard surveyed is experiencing problems on LNG ships with heavy pipe handling in the overhead of large machinery spaces. A summary of findings is included in the Final Report (First Draft).

Reference: See Subsection 4.3 - MATERIALS HANDLING AND STORAGE in the Final Report (First Draft).

#### 3.4.2 PIPE HANGING TECHNIQUES (3.4.2; 3.4.2)

Status: various types of hangers were observed in use at the shipyards surveyed to date but no significant problems were revealed. A summary of techniques and hanger types is included in the Final Report (First Draft).

Reference: See Subsection 4.4-- PIPE HANGING. in the Final Report (First Draft).

#### 3.4.3 PIPE ALIGNMENT TECHNIQUES (3.4.3; 3.4.3)

Status: A general discussion relative to shipboard pipe alignment is provided in the Final Report (First Draft)

Reference: See Subsection 4.5 - PIPE ALIGNMENT in the Final Report (First Draft).

#### 3.4.4 MODULAR SUBASSEMBLIES (3.4.4; not in Proposal)

Status: All shipyards surveyed are attempting to perform as much work as possible in the shop rather than on the ship. This is being accomplished in a variety of ways such as joint design/shop consultations, sketching desirable modular subassemblies from the first completed ship of a class, and reviews of detailed drawings, scale models, and mockups. The most impressive example in this area observed to date was a pre-mounted pump room assembly for an ING. Further, examples of pre-mounted subassemblies were observed during the task effort. Definitions, sketches, and descriptions are included in the Final Report (First Draft).

Reference: See Subsection 3.9 - PIPE SUBASSEMBLIES S in the Final Reprt (First Draft).

#### 3.4.5 PRE-OUTFITTING OF STRUCTURAL SUBASSEMBLIES (3.4.5; not in Proposal)

Status: When shipboard work cannot be accomplished in the shop the next best alternative is to pre-outfit structural subassemblies prior to erection. This is being accomplished in all shipyards surveyed to date and apparently to the greatest extent possible. One shipyard is presently evaluating the possibility of pre-outfitting under-deck piping in the machinery spaces of an ING. This is most desirable due to the size and height of these ships and the volume of large pipe in the overhead. Definitions, sketches, and descriptions are included in the Final Report (First Draft).

Reference: See Subsection 3.9 - PIPE SUBASSEBLIES in the Final Report (First Draft),

#### 3.4.6 PROBLEM AREAS IDENTIFIED (3.4.6; not in Proposal)

Prior to the Advisory Council Meeting on November 22, 1975, one significant problem relative to pipe installation, described below, was identified. This was discussed at the meeting and recommendations were made. Based on these



recommendations, a new task study area was defined and data was collected as noted below.

#### SHIPBOARD WELDING OF LNG PIPING

Status: Several methods of weld preparation of ING cargo piping are presently used. Consumable inserts are used but require considerable time and effort to purge. Backing rings have been used but are not recommended in a recent article of the Welding Journal. Hand TIG welding (after tack welding) using a purge is being done by the French. A general discussion of various techniques is included in the Final Report (First Draft).

Reference: See Subscription 4".6 : PIPE" JOINING in the Final Report (First Draft)

APPENDIX A  
NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY  
PROPOSAL TO ACCOMPLISH  
TASK S-4  
ADVANCED PIPE TECHNOLOGY  
FOR  
BATH IRON WORKS CORPORATION

November 1974

## Section 1

### OBJECTIVE AND SCOPE OF TASK

#### 1.1 OBJECTIVE

The overall objective of Newport News Shipbuilding and Dry Dock Company in pursuing Task S-4 (Advanced Pipe Technology) will be to prepare an end-product software package which will provide comprehensive, standardized, and cost-effective methods for designing, fabricating, and installing commercial ship piping systems. Reduction of engineering calculation and drafting manhours by the use of standardization tables and existing computer programs, and the reduction of fabrication and installation time by the use of advanced techniques will be major areas of study. In addition, the study will be directed to define areas where further technical innovation could significantly reduce the installed-cost of piping systems.

#### 1.2 SCOPE

The entire task will be developed within the scope of existing regulatory body requirements. The end-product of task development will be a software package directly usable by commercial ship-builders. This package will consist of a Final Report, a Design Manual, and a supplementary Fabrication and Installation Manual. The Final Report will present, in both qualitative and quantitative form, the overall results of task development, and will make reference to the Design Manual and the Fabrication and Installation Manual for detailed descriptions of methods. The Design Manual will contain all information on those methods directly usable by engineering and design personnel, as required by the Task Specification. The supplementary Fabrication and Installation Manual - an anticipated by-product of task development - will contain methods outside the scope of the Design Manual but directly usable by fabrication and installation personnel. The intent of this approach is to utilize to the fullest extent the findings of the task.

## Section 2

### METHOD OF TASK DEVELOPMENT

#### 2.1 REVIEW OF EXISTING REGULATORY BODY REQUIREMENTS

In *order* to establish the overall limits of investigation at the outset of task development, Newport News Shipbuilding proposes to conduct an in-depth review of all existing regulations applicable to commercial ship piping systems. As an integral part of this review, those areas where engineering and design time could be significantly reduced by use of standard data reference tables and available computer programs or where fabrication and installation time could be reduced by use of advanced techniques will be noted for further evaluation.

Since the regulatory body requirements-affecting this task n change, some means of updating the end-product software package is vital. This problem will also be studied and recommendations will be made.

#### 2.2 REVIEW OF STATE-OF-THE-ART PIPE TECHNOLOGY

A review of the domestic and foreign state-of-the-art pipe technology will be made with the primary objective of identifying for further study cost-effective methods of designing, fabricating, and installing commercial ship piping systems. Particular areas of emphasis which include pipe calculations (stress and pressure loss), pipe scheming (interference and hole control), pipe bending (semi-automatic and automatic), pipe joining (semi-automatic and automatic welding, slip-flanges and couplings), and pipe hanging. Also, the problems of material availability, ordering, and control along with the related problems of material substitution will be studied.

This review will be conducted via literature searches, in-house and vendor conferences, and field trips. It is anticipated that shipyards in the United States, Western Europe, Far East, and Brazil will be visited. The results of this review will be documented into a standard format for further evaluation. This format will include a description of each promising method and a source listing of software and hardware required to implement each method.

### 2.3 PREPARATION OF METHOD DESCRIPTIONS AND SUPPORTING DATA

The information collected in the reviews of existing regulatory body requirements and state-of-the-art pipe technology will be evaluated for areas of potential improvement and re-grouped *as* necessary into well-defined subject areas. It is anticipated that this process will integrate information on both the software and the hardware aspects of specific subject areas and will lead to the identification of potentially cost-effective methods of piping system design, fabrication, and installation methods for further evaluation. This process will also encourage the development of innovative approaches to producing piping systems.

Once promising methods have been selected, any additional data necessary to make a comprehensive cost analysis will be collected or developed. Method descriptions and supporting data will then be prepared in standard format in such-a-manner that a realistic cost analysis based on quantifiable data can be made. Data for cost analysis will be input on a matrix which will cover all aspects of implementing a particular method.

### 2.4 COST EVALUATION OF METHODS

Cost evaluation will include both the software and hardware aspects of implementing a given method. The evaluation of a given method will include comparisons with existing methods. The output of this process will be the completion of the matrix developed during the preparation of method descriptions and supporting data. In this manner the cost effectiveness of similar methods can be directly compared.

On the basis of the cost evaluation, the relative cost-effectiveness of all methods will be analyzed to determine those which should be recommended for adoption. The results of this analysis will be included in the Final Report.

### 2.5 IDENTIFICATION OF AREAS FOR FUTURE STUDY

During the course of task development, it is anticipated that some cost-effective items will be identified which are outside the scope of the task. A description **of** these items, and appropriate recommendations for future study will be included in the Final Report.

## 2.6 ADVISORY COUNCIL PRESENTATIONS

Two advisory council presentations, as required by the Task Specification, will be given. The response to these presentations will be documented for later reference in re-directing the task development as necessary.

## 2.7 PREPARATION OF END PRODUCTS

The information collected under task development will be organized into the three end products of this task - the Final Report, the Design Manual, and the Fabrication and Installation Manual. Scope and basic content of these documents will be as defined under 1.2-SCOPE above.

# Section 3

## PROPOSED TASK STUDY AREAS

### 3.1 INTRODUCTION

This section briefly describes several proposed task study areas. The following listings are by no means intended to be all-inclusive; they are intended only to be a representative sampling of the most promising cost-effective areas. For convenience, they have been divided into the three basic study areas of design, fabrication, and installation.

### 3.2 PROPOSED DESIGN STUDY AREAS

#### 3.2.1 EON-COMPUTERIZED "QUICK" PIPE CALCULATIONS

The preparation of a convenient reference source, for "rule-of-thumb" and other "quick" methods of preparing pipe calculations is proposed. Such methods are invaluable in cases where, computer use is not warranted or desirable. Extension of such methods to programmable desk calculator techniques will also be investigated.

### COMPUTERIZED PIPE CALCULATIONS

A study is proposed to determine the cost-effectiveness of integrating available computer programs and other software into a standard program which could complete all required pipe calculations from data on a single input form prepared by the engineer.

#### 3.2.3 COMPUTERIZED PIPE DETAILING

MARAD Contract 4-37-097 funded Newport News Shipbuilding to develop a software package for computerized pipe detailing. This package will be available to MARAD in approximately 18 months and will probably be implemented at Newport News Shipbuilding within 18 - 24 months. A feasibility study on the possible extension of this program to print out detail: of piping subassemblies is proposed as part of like--development of Task S-4

#### 3.2.4 PIPE SUBASSEMBLIES

A study of the design, fabrication, and installation of pipe subassemblies is proposed. Impact on storage and handling method will be carefully evaluated.

#### 3.2.5 DRAFTING TECHNIQUES

A study of present drafting techniques is proposed with the objective of simplifying and standardizing to the fullest extent possible all drawings required for piping system production.

#### 3.2.6 PIPE MATERIALS

An investigation of the use of non-ferrous or chrome-manganese steel in lieu of carbon steel materials is proposed. The problem of material availability and material substitution will be included. Impact on fabrication and installation will be studied in detail and life-cycle studies made.

For example, the paper "Shipyard Piping Systems - Cost and Reliability", by Tuthill and Fielding of International Nickel Company, indicates savings with the use of copper-nickel pipe materials. As one area of study, the findings of this paper will be studied and a determination will be made as to the cost-effectiveness of using copper-nickel versus carbon steel piping. Current problems associated with the availability of zinc-coating facilities will be considered.

### 3.2.7 REDUCDTION OF NUMBER OF PIPE SIZES

Many pipe sizes can possibly be eliminated thus simplifying the design process and reducing the number of different fitting sizes to be handled during the fabrication and installation process. A study to determine the most cost-effective combinations is proposed. The end-product of this study would be a decision matrix, the parametex of which could be modified to reflect existing market conditions.

### 3.2.8 PIPE BENDS

A study of the most effective use of short-radius bends in lieu of elbows is proposed.

### 3.2.9 SPECIAL PIPE FITTINGS

An investigation of the cost--effectiveness of rotating Elanges, slip couplings, flexible pipe joints, and constant-flow drain orifice devices is proposed. The constant-flow drain- orifice device, for example, is now being used on Navy vessels to replace conventional steam traps. For a given application, the savings in fabrication and installation costs alone appear to be substantial.

## 3.3 PROPOSED PIPE FABRICATION STUDY AREAS

### 3.3.1 SHOP LAYOUT

A study of existing pipe fabrication shop layouts is proposed, with the overall objective of improving work flow patterns and materials handling. Arrangerment of shops for construction of pipe subassemblies and assembly-line techniques will be considered.

### AUTOMATIC PIPE BENDING

Research of state-of-the-art automated pipe bending is proposed. Interface with computerized pipe detailing will be considered.

### 3.3.3 AUTOMATIC WELDING

Research of state-of-the-art automatic welding is proposed. Both fixed and portable machines will be studied.



### 3.4 PROPOSED PIPE INSTALLATION STUDY AREAS

#### 3.4.1 MATERIALS HANDLING

A general survey of material handling problems is proposed.

#### 3.4.2 PIPE HANGING TECHNIQUES

A study of pipe hanging problems is proposed. Particular attention will be given to standardized pipe hangers.

#### 3.4.3 PIPE ALIGNMENT TECHNIQUES

Problems associated with the proper orientation and alignment of fittings and pipe sections during shop fabrication will be investigated. Among the methods to be analyzed will be the match-marking of pipe, components along the lines of the system currently under development at Electric Boat. - methods of determining the exact relative orientation of two ends of installed pipe will also be studied along with the problems associated with installing the pipe subassemblies described in paragraph 3.2.4.

## Section 4

### BREAKDOWN OF TASK S-4 LEVEL OF EMPHASIS

The following is the anticipated breakdown of the Task S-4 effort. This breakdown is by percentages of total time spent for each of the task development **areas** described in Section 2.

<u>TASK DEVELOPMENT AREA</u>	<u>Level of Emphasis (Percent)</u>
<b>REVIEW</b> OF EXISTING REGULATORY BODY REQUIREMENTS	<b>3 %</b>
REVIEW OF STATE-OF-THE-ART PIPE TECHNOLOGY	<b>3 5 %</b>
PREPARATION OF CANDIDATE ALTERNATIVES	<b>1 2 %</b>
COST EVALUATION OF CANDIDATE ALTERNATIVES	<b>20%</b>
IDENTIFICATION OF AREAS FOR FUTURE STUDY	<b>6%</b>
ADVISORY COUNCIL PRESENTATIONS (INCLUDING PREPARATION)	<b>4%</b>
PREPARATION OF END PRODUCTS	<b><u>20%</u></b>
TOTAL	<b>100%</b>

## ADVANCED PIPE TECHNOLOGY

### TASK S-4

#### PROJECT MANAGER

Joe D. Snyder, Jr.

EDUCATION      Virginia Polytechnic Institute, B. S. Mechanical Engineering, 1939

PROFESSIONAL   Newport News Shipbuilding and Dry Dock Company  
P O S I T I O N S      -Major Assignments included:  
1966 - Present      Engineering Section Manager.  
1952- 1966      Engineering. Technical Department  
1939 - 1952      Engineering Supervisor  
1939 - 1952      Engineering Technical department  
1939 - 1952      Technical Draftsman  
1939 - 1952      Engineering Technical Department

EXPERIENCE      Engineering Management - Technical and supervisory responsibility for the preliminary and detailed engineering design of machinery systems on merchant and naval vessels. Duties include supervision of professional engineering personnel working in piping system functional design and analysis, steam plant performance calculations, the interpretation of ships specifications, the technical review of purchase orders of major components, and the preparation of ships instruction books. Responsibilities also include the management of related developmental programs, such as the recently completed qualification of 2D pipe bending for naval applications.

EXPERIENCE      Machinery Engineering - Perform engineering analyses for steam power plant cycles, heat balance studies, pipe stresses and pressure drops, and ship power plant components performance. Other duties included active participation in ship testing and dock and sea trials.

AFFILIATIONS      Associate member, Society of Naval Architects and Marine Engineers  
Refrigeration Advisory Committee - American Bureau of Shipping  
Member SNAME M-15 (Heat Balance) Panel

## ADVANCED PIPE TECHNOLOGY

### TASK S-4

#### PROJECT ENGINEER

Lamar E. Williams, Jr.

#### EDUCATION

Old Dominion University, 12 hours graduate study,  
Engineering Mechanics (concentrations in solid  
mechanics and materials behavior) , 1972-1974.

Virginia Polytechnic Institute, B.S.,  
Engineering Mechanics ( c o n c e n t r a t i  
mechanics and materias behavior)

Old Dominion College Technical Institute, A.S.,  
Architectural Drafting Technology, 1962. (Special  
recognition for work covering the original design,  
construction, and testing of a solar heating system  
including all related piping systems.)

#### PROFESSIONAL POSITIONS

Newport News Shipbuilding and Dry Dock Company

1970 - Present	Engineer - Engineering Technical Department
1965-1970	Designer - Machinery Design Department
1962-1965	Junior Designer Machinery Design Department

#### EXPERIENCE

Engineering - Mr. Williams' present major engineering responsibilities include the preparation of piping system design calculations and the technical review of piping system diagrams, with particular emphasis on flow requirements and material compatibility. His other responsibilities include the preparation of detailed descriptions and operating instructions for various ship piping systems and the preparation of ship valves technical manuals.

As a project engineer for the MARAD Ship Design Improvement Project, he engaged in research to identify and develop innovative cost-effective alternatives of producing commercial ship piping systems for air conditioning, heating and

refrigeration. The studies involved in this effort included piping system design methods, materials selection, component selection, and fabrication and installation methods. The most promising alternatives were included in the document, "A Report to the U.S. Department of Commerce Maritime Administration for the Ship Design Improvement Project, Contract MA-1-35402."

As an engineering assistant to the Newport News Shipbuilding design departments, Mr. Williams checked piping system arrangement drawings, performed piping and ventilation system design calculations, studied system standardization methods, and made heat transfer calculations for Arctic tanker designs.

PROJECT ENGINEER  
Robert S. Oglesby

EDUCATION      University of Chicago, M.B.A., 1955

                 North Carolina State University, B.S.,  
                 Industrial Engineering, 1953

                 Newport News Shipbuilding and Dry Dock Company  
                 Apprentice School, 1943

MILITARY      U.S. Navy, 1950 - 1951 - Ship Repair  
SERVICE      U.S. Army, 1944 - 1946 - Ship Repair

PROFESSIONAL   Newport News Shipbuilding and Dry Dock Com  
POSITIONS      1967 - Process Engineer  
                 Process Engineering Department

                 American Safety Razor Company

                 1954 - 1957      Senior Industrial Engineer -  
                 Process and Industrial Engineering

                 United States Steel - Gary Sheet and Tin

                 1953 - 1964      Industrial Engineer -  
                 Process and Industrial Engineering

                 Line Supervisor

                 Newport News Shipbuilding and Dry Dock Company

                 1939 - 1944      Shipfitter  
                 Hull Structure Inspector

EXPERIENCE      Engineering - Mr. Oglesby's present major engineering  
                 responsibility is the supervision of process and  
                 industrial engineers. Major areas of work include  
                 analysis and improvement of design information,  
                 manufacture of structural and outfitting ship com-  
                 ponents, installation and testing of ship components,  
                 planning and scheduling of work, documentation of  
                 processes, incentive and cost of labor studies,  
                 capital expenditure justification, facility design  
                 and planning, and implementation of management policies  
                 and programs. His primary areas of concern are  
                 machinery and piping.

As an industrial engineer for the Gary Sheet and Tin Division of United States Steel Corporation, Mr. Oglesby was involved with production and incentive standards, materials standards, capital expenditures plant layout, materials handling, and process improvement. He also served as a line supervisor in charge of the annealing/pickling, slitting, shearing, polishing, and shipping of stainless sheets and coils.

Working as a process and industrial engineer for the American Safety Razor Company, Mr. Oglesby was concerned with process development and improvement, plant layout, and development of labor standards.

AFFILIATIONS    Member - Propeller Club  
                  Member - Society of Manufacturing Engineers

APPENDIX B  
REVIEW OF EXISTING REGULATORY BODY REQUIREMENTS  
DOCUMENTATION



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APPENDIX B  
REVIEW OF EXISTING REGULATORY BODY REQUIREMENTS  
DOCUMENTATION

B.1        GENERAL COMMENTS

During the course of Task S-4 development, 'representatives of the various U. S. shipyards and design agents were asked to present views relative to regulatory body requirements. The essence of these views and those of the Task S-4 project team are summarized in the following paragraphs.

**B.1.1**        MARAD STANDARD SPECIFICATIONS

The MarAd Standard Specifications, written primarily to protect the interests of MarAd and prospective ship owners, do not by their very nature encourage the writing of Ship Detail Specifications which promote the use of novel cost-effective methods by the shipbuilder. This is unfortunate, since it is very often the shipbuilder that is in the best position to reduce ship costs without sacrificing quality.

A case in point is the use of 2D pipe bends to eliminate fittings. It is well within the present state-of-the-art to produce 2D bends with a quality equal in every respect to 3D or 5D bends. The Navy has accepted 2D bends on a qualification test basis; that is, a shipbuilder must demonstrate its capabilities of making satisfactory 2D bends before such bends can be used on a Navy contract. The Navy recognizes that substantial savings can be realized through the use of 2D bends. Yet, many owners apparently are reluctant to allow the use of 2D bends on their ships, either because they do not recognize the savings to be realized or do not believe 2D bends are equal in quality to 3D or 5D bends.

There is little incentive for the shipbuilder to promote cost-saving ideas under the present system, since the difficulties of convincing the design agent, the owner and MarAd would probably cause delays which would result in cost overruns in excess of the savings to be realized. What is needed is a system similar to the Navy's Value Engineering Program, where the shipbuilder is provided with a standard, well-defined, procedure to submit cost-effective ideas, and where any resultant savings are shared between the Navy and the shipbuilder. This system works well, and very substantial cost--reductions have been realized on many Navy contracts.

Another problem cited concerning the MarAd Standard Specifications is that they are not rewritten from one revision to the next to reflect the latest state-of-the-art. Therefore, new methods seldom have a chance to enter the early stages of ship design. This problem was specifically addressed in a previous study performed by Newport News Shipbuilding for MarAd (MarAd Contract **MA-1-35401**, Ship Design Improvement Project). Numerous ship owners, ship operators, and shipbuilders were consulted and a team of NNS researchers spent well over a year making detailed studies of every system on four ship types. Many of these studies reflected a need for changes to the MarAd Standard Specifications few were ever incorporated.

One final item that should be noted is that the use of standard commercial items for marine applications has been discouraged. In some cases this practice has generated negative results. For example, there are standard commercial valves available which are superior to, and cheaper than, comparable marine valves for the same service. Yet, because they are not "marine" valves their use is discouraged.

#### B.1.2 U. S. COAST GUARD REGULATIONS

A wide variance in the nature of shipbuilder/U. S. Coast Guard Inspector relationships was noted during the Task S-4 on-site surveys of domestic shipyards. Some shipbuilders enjoy a very good relationship with local inspectors; others seem to be plagued with problems and subsequent delays. It appears that the source of many problems is a difference of interpretation between the shipbuilder and the local inspectors.

Most shipbuilders surveyed agreed that one source of the problem may be rooted in the fact that the format of present U. S. Coast Guard Regulations is almost impossible to follow, and therefore errors of interpretation can easily be made. Requirements covering a single topic are often scattered throughout the Regulations and invoked portions of ANSI B31.1.

A possible solution to this problem was studied in some detail by the Task S-4 project team. It appears that reader comprehension could be greatly facilitated if U. S. Coast Guard and invoked portions of ANSI B31.1 were combined into a single document. Such a document could also include under each title heading, applicable ABS rules and MarAd specifications. In this way, all related information on a

particular subject could be found in one document under one heading. Paragraphs could be numerically keyed to their original source (U.S. Coast Guard, ANSI, ABS, MarAd) to facilitate updating of the document. Such a document was prepared during this review which proved to be quite helpful in collecting information on various study areas. Sample pages from this document are presented along with appropriate explanatory matter in this Appendix and in Subsection. 2.4 of the Final Report (First Draft).

#### B.1.3 ABS RULES

NO problems were noted during the course of task development relative to ABS Rules, which are oriented primarily toward ensuring the integrity of the ship's hull and propulsion systems. Those sections covering ship piping systems. are, in general, well-written and easily interpreted.

COMMERCIAL SHIP  
COMPOSITE SPECIFICATIONS  
DOCUMENT  
PIPING SYSTEMS

CHAPTER 2  
DESIGN

PART 1  
CONDITIONS AND CRITERIA

**2 . 1**      DESIGN CONDITIONS

2.1.1      GENERAL

MARAD SECTION 11, PIPING-HULL SYSTEMS (1. GENERAL)

All piping shall be concealed in accommodation spaces having ceilings and sheathing, except normally exposed piping to fixtures, and shall be kept to a minimum. In order to maintain maximum headroom, all piping shall be kept behind framing and as close as practical to deck beams, bulkheads, and the underside of decks.

Pipes conveying steam or liquids shall not be led overhead through the emergency generator room, chart room, battery lockers, radio room, refrigerated spaces, stores, dry cargo holds or in the vicinity of switchboards; nor pipes conveying liquids, in food preparation spaces, mess rooms, dispensary, and similar spaces, where avoidable. Where this is not practical, the piping shall have all joints welded or brazed.

All piping subject to mechanical injury shall be adequately protected. All guards shall be bolted in place so that they may be removed for repairs to piping.

USCG **56.07-10**, DESIGN CONDITIONS AND CRITERIA:  
ANSI 101.1, GENERAL

These design conditions define the pressures, temperatures and various forces applicable to the design of power piping systems. Power

pipng systems shall be designed for the most severe condition of coincident pressure, temperature and loading, except as herein stated. The most severe condition shall be that which results in the greatest required pipe wall thickness and the highest flange rating.

#### ABS 36.1.1, GENERAL REQUIREMENTS

All vessels are to be provided with the necessary pumps and piping systems for safe and efficient operation in the service for which they are intended. Materials and workmanship are to be in accordance with the best commercial practice and to the satisfaction of the Surveyor. The arrangements and details are to comply with the following requirements which are applicable to all **ocean-going** vessels but which may be modified for vessels classed for limited service.

#### 2.1.2 PRESSURE

##### USCG 56.07-10, DESIGN CONDITIONS AND CRITERIA: ANSI 101.2, PRESSURE

All pressures referred to in this (ANSI) Code are expressed in pounds per square inch above atmospheric pressure, i.e. psi gage, unless otherwise stated.

##### **USCG 56.07-10, DESIGN CONDITIONS AND CRITERIA:** ANSI 101.2.2, INTERNAL DESIGN PRESSURE

The internal design pressure including the effects of static head shall not be less than the maximum sustained fluid operating pressure within the piping, and shall include allowance for pressure surges, except as these conditions may be modified by the provisions of (ANSI) Para 102.2.4, 102.2.5, 102.3.2 and 102.3.3.

##### USCG 56.07-10, DESIGN CONDITIONS AND CRITERIA: ANSI 101.2.4, EXTERNAL DESIGN PRESSURE

Piping subject to external pressure shall be designed for the maximum differential pressure anticipated during operating, shut-down, or test conditions.

USCG 56.07-10(a), MAXIMUM ALLOWABLE WORKING PRESSURE

- (1) The maximum allowable working pressure of a piping system shall not be greater than the internal design pressure defined in 104.1.2 of ANSI-B31.1.
- (2) Where the maximum allowable working pressure of a system component, such as a valve or a fitting, is less than that computed for the pipe or tubing; the system pressure shall be limited to the lowest of the component maximum allowable working pressures.

USCG 56.-07-10(b), RELIEF VALVES

- (1) Every system which may be exposed to pressures higher than the system's maximum allowable working pressure shall be safeguarded by appropriate relief-devices: (See 52.01-3 of this (USCG) subchapter for definitions.) Relief valves are required at pump discharges except for centrifugal pumps so designed and applied that a pressure in excess of the maximum allowable working pressure for the system cannot be developed.
- (2) The relief valve setting shall not exceed the maximum allowable working pressure of the system. Its relieving capacity shall be sufficient to prevent the pressure from rising more than 20 percent above the system maximum allowable working pressure. The rated relieving capacity of safety and relief valves used in the protection of piping systems shall only be based on actual flow test data and the capacity shall be certified by the manufacturer at 120 percent of the set pressure of the valve.
- (3) Relief valves shall be certified as required in Part 50 of this (USCG) subchapter for valves, and shall also meet the requirements of 54.15-10 of this (USCG) subchapter.

ABS 36.1.2; PIPING GROUPS

To distinguish between detail requirements on the various systems the piping on shipboard is divided into two groups.

Group I in general includes all piping intended for working pressures or temperatures in various services as follows.

Service	Pressure k9/cm <sup>2</sup> (psi)	Temperature C(F)
Vapor and Gas	over 10.5(150)	over 343(650)
Water	over 15.8(225)	over 177(350)
Lubricating Oil	over 15.8(225)	over 204(400)
Fuel Oil	over 10.5(150)	over 66(150)
Lethal* Gases and Liquids	all	all

\* For definition of lethal gases and liquids see 30.13.3d

Group II includes all Piping intended for working pressures and temperatures below those "stipulated under Group I, cargo-oil and tank-cleaning piping, and in addition such open-ended lines as drains, overflows, vents and boiler escape pipes.

APPENDIX C  
REVIEW OF STATE-OF-THE-ART PIPE TECHNOLOGY  
LITERATURE SURVEY DOCUMENTATION



SECTION C.1  
LIST OF PERIODICALS SURVEYED  
(SECONDARY SOURCES)

Periodical Title	Period Covered	
	Beginning	Ending
1. American Machinist	January 1970	March 1976 (Selected Issues Only)
2. Business Week		
3. Industry Week		
4. Iron Age		
5. Machine Design		
6. Management Review		
7. Marine Engineer and Naval Architect		
8. Materials Engineering		
9. Mechanical Engineering		
10. Naval Engineers Journal		
11. Ocean Industry		
12. Sea Power		
13. Sea Trade		
14. Shipbuilding and Engineering Record		
15. Shipping International		
16. U. S. Department of Commerce News		
17. U. S. News and World Report		

SECTION C. 1  
LIST OF PERIODICALS SURVEYED  
(PRIMARY SOURCES )

periodical Title	Period Covered	
	<u>Beginning</u>	<u>Ending</u>
1. Engineering Index	January 1970	March 1976
2. Fairplay International		
3. Japan Shipbuilding and Marine Engineering		
4. Marine Engineering/Log		
5. Marine Engineers Review		
6. Marine Technology		
7.- Maritime Reporter and Engineering -- News		
8. M o t o r S h i p		
9. Norwegian Shipping News		
10. Sea Technology		
11. Shipbuilding International (Formerly Shipbuilding and Marine Engineering International)		June 1972
12. Shipbuilding and Shipping Record		June 1974
13. Shipping World and Shipbuilder		March 1976
14. Surveyor		August 1975
15. Tanker and Bulk Carrier		May 1975
16. Zosen		March 1976

SECTION C. 2  
LIST OF SIGNIFICANT ARTICLES  
AND  
PUBLICATIONS  
(CATEGORY I)

# GENERAL SHIPBUILDING TECHNOLOGY

Article or Publication		
<u>Title</u>	<u>Author(s)</u>	<u>Source</u>
<u>A Sweedish Computer System for Entire Ship Design and Production</u>	Not given	Shipbuilding and Engineering Record, March 27, 1970
<u>Shipbuilding - A World Leader in Computer Application</u>	Not given	Shipbuilding and Shipping Record - Marine Design International, April 1973
<u>Metrication of U. S. Shipbuilding</u>	C. Jeien	Naval Engineers Journal, April 1973
<u>Numerical Control with Particular Reference to Shipbuilding</u> (Paper)	J. E. Chadbund	N. E. Coast Institution of Engineers and Shipbuilders-Transactions Vol 89, No. 5, May 1973
<u>Numerical Control in Shipbuilding</u>	J. E. Chadbund	Shipbuilding and Shipping Record, April 20, 1973
<u>Interactive Graphics for Computer-Aided Design</u> (Book)	M. D. Prince	Not given

# PIPING DESIGN/ENGINEERING TECHNOLOGY

Article or Publication Title	Author(s)	Source
<u>A Brief Overview of Modern Advanced Piping Technology</u>	J. R. Salzer	Ship" Tech Associates 1974
<u>Use of Scale Models as a Management Tool</u> (Report)	'Bath Iron works Corp.	U. S. Department of Commerce - Maritime Administration, May 1974
<u>Arrangement of Shipboard Piping by-Digital Computer</u>	J. B. Woodward	Marine Technology, April 1975
<u>Computer Graphics in the Shipbuilding Industry - A Feasibility Study</u>	R. W. Green	The Swedish Shipbuilders Computing Center
<u>Interactive Computer Graphics and the Marine Industry</u>	A. C. Landsburg F. Seibold	Marine Technology, July 1975
<u>Computer Aided Piping Engineering System at Italcantieri Co. (Paper)</u> May 1972, presented at Autokon Users Club Meeting, St. Nazaire, France	Dr. Luigi Oliva et al	Italcantieri Co. Sede & Direzione Generale 34132 Trieste Corso Cavour N. 1
<u>Computer Aided Design and Production in a Multi-yards Organization - Status and Trends (Paper)</u> August 1973, . presented at the internation- al Conference on Computer Applications in the Auto- mation of Shipyard Operation and Ship Design, Tokyo, Japan	Dr. Luigi Oliva et al	Italcantieri Co. Sede & Direzione Generale 34132 Trieste Corso Cavour N: 1
<u>Computers in the Design Department to Control Shipboard Interferences</u>	J. K. McNeal R. P. Kakad J. S. Magrie	Maritime Reportar/ Engineering News, June 15, 1975

Article or Publication Title	Author(s)	Source
<u>Interference Control System</u> (Booklet) presented at the 27 February 1973 meeting of the Delaware Valley Section of the American Society of Naval Engineers	J. K. McNeal R. P. KaKad J. S. Magrie	Sun Shipbuilding & Drydock co. <b>Chester, Pennsylvania</b>
<u>Report on Interference Control Systems and on the DEPICTS Proposal by L. C. Higbie and R. F. Mullen in Relation to Existing Interference Control Systems (Report to SNAME Computer Aids to Shipbuilding Task Group 0-34-1) dated June 1, 1973</u>	G. C. Corley, Jr. J. A. Schiro	Society of Naval Architects and Marine Engineers, <b>Ship Pro- duction Committee Task Group 0-34-1</b> 74 Trinity Place New York, N.Y. 10006
<u>Materials to Fight Marine Environment</u>	K. Masubuehi	Materials Engineering, Special Report, January 1971
<u>The Promise of Unforgiving Materials</u>	D. Groves	Naval Engineers Journal December 1971
<u>Plastics: Ideal Seagoing Materials That Chop Maintenance Costs</u>	Not given	Marine Engineering/ Log, July 1972
<u>U. S. Navy Develops New Way to Drain HP Steam Lines and Cuts Costs</u>	L. L. Gusick	Marine Engineering/Log
<u>Condensate Removal Device</u>	Not given	Mechanical Engineering January 1975

# PIPING FABRICATION/INSTALLATION TECHNOLOGY

Article or Publication <u>title</u>	Author(s)	Source
<u>Mitsui-Developed</u> <u>Automated Pipe Shop</u> <u>System in Use at</u> <u>Chiba Works</u>	Not given	Unknown
<u>MAPS System</u> (Paper)	S. Moriguehi --	Mitsui Shipbuilding and Engineering Co., Ltd. Chiba Works, Japan-.
<u>Recent Developments in</u> <u>Shipyard Welding</u>	W. C. Brayten	Marine Technology July 1975
<u>Continuous Welding Robot</u>	Not given	Mechanical Engineering April 1975
<u>Application of Preoutfitting</u> <u>During Construction of</u> <u>Animunition Ships AE 32-35</u>	R. A. Goldbach	Marine Technology, January <b>1973</b>
<u>Marine Pipe Fitting</u> (Book)		Pennsylvania Department of Public Instruction
<u>pipe Bending Machines</u> <u>for Shipbuilding</u>	J. Houmack	British Shipbuilding Research Association Research Report No. PS15J

SECTION C.3  
LIST OF SIGNIFICANT ARTICLES  
AND  
PUBLICATIONS  
(CATEGORY II)



# BRAZIL

Article or Publication Title	Author(s)	Source
<u>Ishikawajima do Brasil</u> <u>Estaleiros S.A. Greets</u> <u>Its 10th Anniversary</u> <u>Establishment</u>	M. Ikeuchi	Japan Shipbuilding and Marine Engineering (July 1969)
<u>Shipbuilding in Brazil</u>		Shipping International (September/October <b>1 9 7 2</b> )
<u>Bright Outlook for</u> <u>Expanding Brazillian</u> <u>Shipbuilding Industries</u>		Motor Ship (October 1973)

# D E N M A R K

Article or Publication		
Title	Author(s)	Source
<u>Odense Steel Shipyard, Ltd.</u> (Odense, Denmark)		NNS Trip Report August 19, 1969
<u>Burmeister and Wain</u> (Copenhagen, Denmark)		NNS Trip Report August 20, 1969
<u>Booming Odense Plans</u> <u>Further Expansion</u>		Shipbuilding and Shipping Record - Supplement <b>May 1, 1970)</b>
Giant Tankers at-Odense		Fairplay International (April 24, 1971)
<u>Odense Steel Shipyard</u>		Shipbuilding International (June 1971)
<u>Danish Shipbuilding at</u> Mid-1972		Norwegian Shipping News (Nr. 17D, 1972)
<u>Burmeister and Wain</u> (Copenhagen, Denmark)		NNS Trip Report May 5, 1972)
<u>Odense Steel Shipard, Ltd.</u> (Odense, Denmark)		NNS Trip Report May 9. 1972
<u>Denmark - Open Season</u> <u>for Mavericks</u>		Fairplay International Shipping Journal (July 5, 1973)
<u>The Lindo Shipyard</u>		Shipbuilding and Shipping Record/Marine Week Special Issue (May 1974)

FINLAND

Article or Publication Title	Author(s)	Source .
<u>Wartsila - Finland's Largest Shipbuilding Enterprise</u>	E.E.B. Holmstrom	Shipbuilding and Shipping Record (March 28, 1969)
<b><u>New Helsinki Yard for Valmet Oy</u></b>		Fairplay International Shipping Journal (January 1972)
<u>Finnish Shipbuilders Quietly-Optimistic"</u>		Norwegian Shipping News (Nr. 17D, 1972)

# FRANCE

Article or Publication Title	Author,(s)	Source
<u>Chantiers De L'Atlantique</u> (Saint Nazaire, France)		NNS Trip Report (August 21, 1969)
<u>Gas Ships Are This French</u> <u>Yard's Main Interest</u>		Shipbuilding and Shipping Record (October 22, 1971)
<u>Stabilization within the</u> <u>French Shipbuilding</u> <u>Industry</u>		Norwegian Shipping N e w s (Nr. 17D, 1972)

# ITALY

Article or Publication		
<u>Title</u>	<u>Author(s)</u>	<u>Source</u>
<u>Italcantieri - Present Accomplishments and Future Prospects</u>		Fairplay International Shipping Journal (July 5, 1972)
<u>Italy - Merchant Fleet Increases</u>		Fairplay International Shipping Journal (JULY 5, 1973)
<u>IHI to Export Ship Method to Italy's Shipyard</u>	<u>Fitting Largest</u>	Norwegian Shipping News (No. 14, 1973)

JAPAN

Article or Publication		
Title	Author(s)	Source
<u>The Tsu Shipyard of Nippon Kokan kabushika Kaisha</u>		Tanker and Bulk Carrier (January 1970)
<u>Planning for the- Construction of Tsu Shipyard</u>	A. Hayashi	Marine Technology (April 1970)
<u>Nippon Kokan Shipyard at Tsu</u>		<b>International:</b> Shipbuilding (June 1970)
<u>New Mitsubishi Yard with 500,000 - Ton Capacity Building Dock</u>		Shipbuilding and Shipping Record (September 11, 1970)
<u>Japanese Shipbuilding Goes Maxi</u>	K. Masubuchi	Iron Age (November 5, 1970)
<u>Nippon KoKan - Japan's Only Steelmaker - Shipbuilder</u>		Fairplay Japanese Shipping Survey (June 18, 1970)
<u>At Mitsubishi, Nagasaki- Simultaneous Two-Part Construction</u>		Tanker and Bulk Carrier (October 1970)
<u>Modernized Installation and New Production System for Building Mammoth Sized Vessels - Sakai Shipyard, Hitachi Zosen</u>		Japan Shipbuilding and Marine Engineering (Volume 5, No. 2, 1970)
<u>Mitsubishi's Major Trends in the 1970's</u>		Shipbuilding International (April 1971)
<u>Sumitomo's Oppama Shipyard Commences Operation</u>		Zosen (February 1972)
<u>MHI's Koyagi Shipyard Nearing Completion</u>	M. Chihaya	Zosen (May 1972)

## JAPAN

Article or Publication Title	Author(s)	Source
<u>Shipbuilding - All That's New Installed at Sumitomo's Oppama Yard</u>	S.L. Jones	Seatrade (May 1972)
<u>How Big Can You Get in Shipbuilding</u>	-	Norwegian Shipping News (Nr. 16, 1972)
<u>How Recent Events Have Affected Japanese Shipbuilding</u>	-	Norwegian Shipping News (Nr. 17D, 1972)
<u>Pushbutton Shipbuilding (At Nippon KoKan)</u>	-	American Machinist (February 19, 1973)
<u>Japan - Record Year for Shipbuilders</u>	-	Fairplay International Shipping Journal (July 5, 1973)
<u>A Survey of the Japanese Yards</u>	-	Norwegian Shipping News (No. 16, 1973)
<u>Shipbuilding - Japan Loads Beyond the Three-Year Order Book</u>	S. L. Jones	Seatrade (August 1973)
<u>Hitachi Ariake Shipyard for ULCC's Under Construction</u>	-	Shipbuilding and Shipping Record (September 7, 1973)
<u>Hitachi Ariake Shipyard Commences Operation</u>	-	Zosen (August 1973)
<u>Introduction of New Oppama Mammoth Shipyard of Sumitomo Shipbuilding and Machinery Co., Ltd.</u>	-	Japan Shipbuilding and Marine Engineering (Volume 7, No. 1, 1973)

# NORWAY

Article or Publication		
Title	Author(s)	Source
A/S Stord Verft (Stord, Norway)		NNS Trip Report (August 25, 1969)
Aker Group - Norway's Biggest Marine Concern		Shipbuilding and Shipping Record Supplement (May 1, 1970)
Wide Variety of Standard and Specialized Tonnage Keeps Norwegian Yards Busy		Shipbuilding and Shipping Record (May 26, 1972)
Guarded Optimism Among Norwegian Shipbuilders		Norwegian Shipping News (NR. 17D, 1972)
Norway - Considerable ship Ordering		Fairplay International Shipping Journal (July 5, 1973)



# PORTUGAL

Article or Publication Title	Author(s)	Source
<u>Setenave - A Vast New Portuguese Shipyard</u>		Motor Ship (November 1972)
<u>Setenave - Portugal's New Shipbuilding and Repair Facility</u>		Shipping World and Shipbuilder (November 1972)
<u>Portugal's Second Large Shipyard</u>		Shipbuilding and Marine Engineering International (February 1973)

SPAIN

Article or Publication Title	Author(s)	Source
<u>The Spectacular Rise of Spanish Shipbuilding</u>	-	Shipbuilding and Shipping Record (April 1971)
<u>Spanish Shipbuilding</u>	-	Fairplay Spanish Shipping and Ship- building Survey (May 20, 1971)
<u>Shipbuilding in Spain</u>	-	Shipping World and Shipbuilder (January 1972)
<u>Spain's Shipbuilding Vitality</u>	-	Surveyor (February 1972)
<u>Spain's Rising Status in World Shipbuilding</u>	-	Seatrade (February 1972)
<u>Large-Scale Shipbuilding in Spain</u>	-	Norwegian Shipping News (Nr. 17D, 1972)
<u>Spain - Economy Progressing at a Fair Pace</u>	-	Fairplay International Shipping Journal (July 5, 1973)

SWEDEN

Article or Publication Title	Author(s)	Source
<u>Kockums Shipyard</u> (Malmo, Sweden)	-	NNS Trip Report August 18, 1969
<u>Gotaverken Shipyards</u> <u>Arendal Yard</u> (Gothenburg, Sweden)	-	NNS Trip Report August 26, 1969
<u>Gotaverken - Dedicated to</u> <u>Series Production</u>	-	Shipbuilding and Shipping Record - Supplement (May 1, 1970)
<u>Swedish Yards Cannot</u> <u>Compete Against</u> <u>Foreign Governments</u>	-	Shipbuilding and Shipping Record Supplement (May 1, 1970)
<u>Modernized Kockums</u> <u>Yard Still Looking</u> <u>for Profits</u>	-	Shipbuilding and Shipping Record - Supplement (May 1, 1970)
<u>S.Kr. 40m Reconstruction</u> <u>of Oresundsvarvet</u>	-	Shipbuilding and Shipping Record (October 2, 1970)
<u>Reconstruction of</u> <u>Oresundsvarvet</u>	-	Tanker and Bulk Carrier (November 1970)
<u>Improved Shipyard</u> <u>Facilities for</u> <u>Gotaverken Group</u>	-	Shipping World and Shipbuilder (December 1970)
<u>Modernization</u> <u>at Landskrona</u>	-	Shipbuilding International (November 1970)
<u>Improvements at One of</u> <u>Sweden's Big Yards</u>	-	Marine Engineering/Log (February 1971)

SWEDEN

Article or Publication Title	Author(s)	Sources
<u>Eriksberg Yard</u>	-	Shipping World and Shipbuilder (February 1971)
<u>Kockum's Formula for Success</u>	-	Fairplay International (July 15, 1971)
<u>Kockum's - Europe's Largest Shipyard</u>	-	Fairplay International (April 1972)
<u>Gotaverken Shipyards - Arenda Yard</u> (Gothenburg, Sweden)	-	NNS Trip Report (May 10, 1972)
<u>Sweedish Shipbuilding - Not Too Worried Yet</u>	-	Shipbuilding and Shipping Record (May 26, 1972)
<u>Oresundsvaret's Shipyard Reconstruction</u>	-	Fairplay World Shipyards Survey (July 27, 1972)
<u>Gotaverken: A Special Survey</u>	-	Motor Ship (October 1972)
<u>Improved Prospects for Shipbuilding on Long-Term Says Sweden</u>	-	Norwegian Shipping News (Nr. 17D, 1972)
<u>Record Tonnage from Eriksberg in 1972</u>	-	Fairplay International (May 3, 1973)
<u>The Company That Published Its Shortcomings</u>	R. Hill	Management Review (July 1973)
<u>Sweden - Yards See Profitable Years Ahead</u>	-	Fairplay International Shipping Journal (July 5, 1973)

## THE NETHERLANDS

Article or Publication Title	Author(s)	Sources
<u>Verolme-Dock and Shipbuilding</u> Co. (Rotterdam, The Netherlands)		NNS Trip Report (August 26, 1969)
<u>Varied Work at N.D.S.M.</u>		Fairplay International (September 1970)
<u>Rhine-Schelde - Verolme</u> <u>Has a Prosperous</u> <u>First year</u>		Shipbuilding and Shipping Record (June 30, 1972)
<u>The Dutch Shipbuilding</u> <u>Industry</u>		Norwegian Shipping News (Nr. 17D, 1972)
<u>Indoor Shipbuilding</u> <u>at Kinderdijk</u>		Shipbuilding and Marine Engineering International (February 1973)
Holland Applies Modern Technology to Expedite <u>Shipbuilding Schedules</u>		Ocean Industry (July 1973)
Holland-Successful <u>Start to Year for</u> Owners		Fairplay International Shipping Journal (July 5, 1973)
<u>Some Aspects of Dutch</u> <u>Shipbuilding in 1972</u>		Norwegian Shipping News (No- 2A, 1973)

UNITED KINGDOM

Article or Publication Title	Author(s)	Sources
<u>Harland and Wolff</u> (Belfast, Ireland)	-	NNS Trip Report (August 25, 1969)
<u>British Shipbuilding in 1972</u>	-	Norwegian Shipping News (Nr. 17D, 1972)

U.S.A.

Article or Publication Title	Author(s)	Sources
<u>The System at NASSCO Works</u>	-	Maritime Reporter/ Engineering News (January 15, 1969)
<u>Ingalls West: Yard of the Future</u>	-	Iron Age (February 12, 1970)
<u>General Dynamics - Quincy</u>	-	Marine Engineering/Log (May 1970)
<u>Modular Shipbuilding in America</u>	-	Shipbuilding International (May 1970)
<u>Highly Integrated Ship Production Facility in Operation at Pascagoula</u>	-	Motor Ship (June 1970)
<u>Gulf Coast Shipyards ... \$ Millions for Modernization</u>	-	Marine Engineering/Log (July 1970)
<u>Upgraded Facilities Gives Ingalls Complete Complex</u>	-	Marine Engineering/Log (July 1970)
<u>Lockheed</u>	-	Marine Engineering/Log (September 1970)
<u>West Coast Yards ... Expanding for the 70's</u>	-	Marine Engineering/Log (September 1970)
<u>Decisive Year for U.S. Shipyards</u>	-	Fairplay International Shipping Journal (September 3, 1970)
<u>New 300,000 dwt Facility at Sparrows Point Shipyard</u>	-	Shipbuilding and Shipping Record (July 23, and 30, 1971)
<u>Bethlehem Ready to Build the 300's</u>	-	Tanker and Bulk Carrier (August 1971)

Article or Publication Title	Author(s)	Sources
<u>Whatever Happened to the Nixon Maritime Program?</u>	I. M. Heine	Sea Power (May 1972)
<u>Yards Have Biggest Backlog since 1958; More Big Orders Seen</u>		Marine Engineering/I (June 1972)
<u>I Management Problems in Shipyards</u>	K. Douglas	Shipbuilding and Marine Engineering International ( July 1972 )
<u>U.S.A. - Commercial Shipbuilding Programme Gains Momentum.</u>	J. J. Reynolds	Fairplay International Shipyard Journal (July 6, 1972)
<u>Remarks by Robert J. Blackwell, Assistant Secretary of Commerce for Maritime Affairs at Seminar on Financing the U.S. Merchant Fleet in the Seventies, San Francisco, California</u>		U.S. Department of Commerce News (November 30, 1972)
<u>Prospects Improve for U.S. Shipbuilding</u>		Norwegian Shipping News (Nr. 17D, 1972)
<u>A Correspondent's View Of U.S. Shipbuilding</u>		Norwegian Shipping News (Nr. 17D, 1972)
<u>Information on Some U.S. Yards</u>		Norwegian Shipping News (No- 22, 1972)
<u>New Shipbuilding Dock at the Sparrows Point Yard</u>	Foster	Marine Technology (January 1973 )
<u>Shipyards Launch Biggest Salvage Job</u>		Industry Week (January 22, 1973)



# U.S.A.

Article or Publication		
Title	Author(s)	Sources
<u>U.S. Shipyards Are Back in the Building Race</u>		Business Week (April 7, 1973)
<u>A Ship (and Shipyard) Grows in Brooklyn</u>		Marine Engineering/Log (May 1973)
<u>From "Old Ironsides" to JEFF, SWATH and DFH (Us. shipyards: The Wellsprings of American Sea Power)</u>	N. Polmar K. W. Sayers	Sea Power (May 1973)
<u>American Owners Are Pulling Back</u>		Marine Engineering/Log Yearbook Issue (June 15, 1973)
<u>U.S. Cargo-Lines Industry: Distress Signals</u>		Fairplay International Shipping Journal (July 5, 1973)
<u>U.S.A. - A Great Year for Shipbuilders</u>	E. M. Hood	Fairplay International Shipping Journal (July 5, 1973)
<u>Full Steam Ahead for Shipbuilding in the U.S.</u>		U. S. News and World Report (July 23, 1973)
<u>The Oceanic Superpowers</u>	N. Polmar K. W. Sayers	Sea Power, (August 1973)
<u>U.S. Concern May Get IHI Technical Assistance for Building ULDC, VLCC</u>		Z o s e n (September" 1973)

WEST GERMANY

Article or Publication Title	Author(s)	Sources
<u>A.G. "Weser" Shipyard</u> (Bremin, W. Germany)		NNS Trip Report August 18, 1969
<u>Kieler Howaldtswerks Shipyard</u> (Kiel, W. Germany)		NNS Trip Report August 20, 1969
<u>Flenders Shipyard</u> (Lubeck), W. Germany)		NNS Trip Report August 21, 1969
<u>A. G. "Weser" Shipyard</u> (Bremin, W. Germany)		<b>NNS Trip Report</b>
<u>The German Shipping Industry</u>		Norwegian Shipping News (Nr. 17D, 1972)
<u>West Germany - Shipards Well Engaged</u>		Fairplay International Shipping Journal <b>(July 1973)</b>

SECTION C.4  
LIST OF SIGNIFICANT ARTICLES  
AND  
PUBLICATIONS  
(CATEGORY III)

# GENERAL SHIPBUILDING TECHNOLOGY

Article or Publication	Author(s)	Sources
Title		
<u>Marine Service</u>	Commercial Brochure	Marine Service GMBH 2000 Hamburg 11 Mattentwiele 1, W. Germany

# PIPING DESIGN?ENGINEERING TECHNOLOGY

Article or Publication Title	Author(s)	Sources
<u>Newport News Shipbuilding and Dry Dock Company - Piping Design Manual</u>	Company Document	(not available)
<u>The Decider System - Computerized Design Assistance</u>	Commercial Brochure	Computerized Interference Elimination, Inc. - 14230 N.E. 8th St. Bellevue, Washington 98007
<u>Detector - A Computer Program for the Detection of Physical Interference in Piping and for the Determination of Interference Free Paths</u>	Commercial Brochure	Bernard J. Karites Park Lane Harvard, Massachusetts 01451
<u>IHI - CADS (Conversational Analyzer and Drafting System)</u>	Commercial Brochure	Ishikawajima - Harima Heavy Industries, Ltd. Suite 1101 One World Trade Center New York, N. Y. 10048

# PIPING FABRICATION/INSTALLATION TECHNOLOGY

Article or Publication Title	Author(s)	Sources
<u>MAPS System - Mitsui Automated Pipe Shop System</u>	Commercial Brochure	Mitsui Shipbuilding and Engineering Co. Ltd 6-4 Jsukiji 5 Chome Chvo-Ku Tokyo, 104 Japan
<u>Automatic Pipe Processing System</u>	Commercial Brochure	Ishikawajima-Harima Heavy Industries, Ltd. Suite 1101 One World Trade Center New York, N.Y. 10048
<u>Pipe and Tube Bending for the Shipbuilding Industry</u>	Booklet	Teledyne Pines 601 West New York St. Aurora, Illinois 60506
<u>Basic Guide to Tube Bending</u>	Commercial Brochure	Conrac Corporation Machine Tool Division 9200 Bolsa Avenue Westminster, Ca. 92683
<u>Oxytechnik</u>	Commercial Brochure	(not available)

APPENDIX D  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)

APPENDIX D  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)

LIST OF FACILITY SURVEYS

SECTION NO.    PAGE NO.

SHIPYARDS - EAST COAST

1.	Bath Iron Works Corporation	D.1	D-1
2.	Seatrain Shipbuilding Corporation	D.2	D-4
3.	Quincy Shipbuilding Division of General Dynamics Corporation		D-6
4.	Sun Shipbuilding and Dry Dock Company,	D . 4	<del>D-9</del>
5.	Bethlehem Steel. Corporatioa Sparrows Point Yard	D . 5	D - 1 2
6.	Newport News" Shipbuilding and Dry Dock Company	D . 6	D-15

SHIPYARDS - GULF COAST

1.	Ingalls Shipbuilding Division of Litton Industries, Inc.	D.7	D-21
2.	Avondale Shipyards, Inc.	D.8	D-25

SHIPYARDS - WEST COAST

1.	National Steel and Shipbuilding Company	<b>D.9</b>	D-26
2.	Todd Shipyards Corporation Los Angeles Division, San Pedro Y a r d	D.10	D - 3 0
3.	FMC Corporation	D . 1 1	D-31
4.	Lockheed Shipbuilding and Construction Company	D - 1 2	D-33
5.	Todd Shipyards Corporation Seattle Division	D . 1 3	D-36

DESIGN AGENTS

1.	Gibbs and Cox, Inc.	D.14	D-39
2.	J. J. McMullen, Inc.	D.15	D-40
3 .	M. Rosenblatt and Son, Inc.	D . 1 6	D-42
4.	George G. Sharp, Inc.	D . 1 7	D-43



APPENDIX D  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)

LIST OF FACILITY SURVEYS

SECTION NO. PAGE NO.

PIPING FABRICATORS

- |   |      |      |
|---|------|------|
| 1. Crippen Pipe Fabrication Corporation | D.18 | D-45 |
| 2. Cosmodyne Corporation                | D.19 | D-47 |

PIPING FABRICATION EQUIPMENT MANUFACTURERS

- |                       |      |      |
|-----------------------|------|------|
| 1. Teledyne Pines     | D.20 | D-49 |
| 2. Conrac Corporation | D.21 | D-50 |

RESEARCH FACILITIES

- |  |      |      |
|--|------|------|
| 1. Naval Ship Research and Development<br>Center | D.22 | D-52 |
|--|------|------|

SHIPYARDS  
-EAST COAST-

SECTION D. 1  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
BATH IRON WORKS CORPORATION

D.1.1 INTRODUCTION

A tour of Bath Iron Works Corporation, located in Bath, Maine, was conducted on November 19, 1975 for the purpose of collecting pipe technology data. Additional data was collected via correspondence and telephone interviews.

In general, Bath is a versatile yard which has been involved in the construction of Navy destroyers, MSC tankers, and container ships. They are currently one of two U. S. yards-involved in-the construction of RO/RO ships.

As of April 1, 1976 the following ships were under contract at Bath:

Quantity	Type	Propulsion	Size
4	RO/RO	Steam Turbine	14,500 dwt
1	Patrol Frigate (FFG-1)		

A brief description of the piping design, fabrication, and installation activities at Bath is given in the following paragraphs. This description is current to April 1, 1976.

D.1.2 DESIGN

In general, Bath has relied heavily upon design agents for much of its preliminary and detail design work. It was noted that Bath's longstanding relationship with Gibbs and Cox, Inc. has resulted in an excellent design agent/builder environment. Normally, the design agent does all required design work through the first revision of a drawing. Any subsequent revisions to drawings that may be required are handled by Bath's own small competent design staff.

Since Bath is involved in very little original design work, no details on design practices could be given. It should be noted, however, that pipe details are usually

prepared by the pipe shop. Also, Bath's material control system appears to be one of the best in the U. S. ship-building industry. No details were available on the system.

#### D.1.3 FABRICATION

A tour through the pipe shop at Bath revealed some interesting features. A rather unique pipe storage and delivery system was developed to solve the problem of limited pipe storage areas within the pipe shop. Pipe is stored in racks adjacent to the shop and in-line with the general flow path of material through the shop. When a piece of raw pipe is required, it is taken from the rack and placed on a conveyor which passes the pipe through an opening in the shop wall and on to the pipe cut-off machine. At the cut-off machine the pipe is then positioned and cut to length. Either a flame or saw cut-off-method is used, depending upon the material and size of the pipe.

Pipe requiring bending is moved to the pipe bending area and bent in accordance with pipe detail sheets prepared in the shop. Material for further fabrication of the pipe is pre-ordered and stored, ready for use, in accordance with production control schedules. After pipe and fittings have been fabricated, finished pieces are either-sent to the ship or to the pre-outfitting area. Pre-outfitting is accomplished to the greatest extent possible, either in the structural fabrication shop or on platens outside the shop.

The pipe shop at Bath is equipped with a variety of saws, benders, burning equipment, work benches, etc., all of which provide the flexibility that Bath requires to handle a mix of ship types and sizes.

#### D.1.4 INSTALLATION

A tour of the RO/RO. ships under construction at Bath was provided. It was noted that the open areas below main deck were being utilized for an on board pipe shop. Pipe storage racks and fabrication equipment were suet up to handle on board working of pipe not fabricated in the shop. This pipe shop allowed pipefitters to accomplish much of the shipboard work under near-shop conditions. This is a great advantage since climatic conditions at Bath in the winter are quite severe for shipbuilding; it is not uncommon for temperatures on the shipways to drop to -20°F.

The concept of an on board pipe shop could perhaps be applied at other U. S. yards in order to gain the obvious advantages for pipe installation personnel.

The general layout of pipe runs observed during the tour reflected excellent planning. The level of activity aboard ship indicated a smooth, well-planned effort to expedite the installation of shipboard piping with a minimum of disruption and delay.

#### D.1.5 ACKNOWLEDGEMENTS

For their kind assistance in providing us with an excellent tour of Bath Iron Works Corporation, we wish to thank the following people:

R. G. Ford - Project Manager, Ship Producibility Program

R. W. Thorpe, Jr. - Program Manager, Ship Producibility Program

R. Grondin - Chief Machinery Draftsman

L. Totten - Chief Test Engineer

H. Hatch - Pipe Shop Superintendent

C. Bower - Pipefitting Foreman

SECTION D. 2  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
SEATRRAIN SHIPBUILDING CORPORATION

D.2.1 INTRODUCTION

A tour of Seatrain Shipbuilding Corporation located in Brooklyn, New York (Brooklyn Navy Yard), was conducted on February 19, 1976 for the purpose of collecting pipe technology data. Additional data was collected via telephone interviews.

Seatrain has made a remarkable recovery from past financial difficulties and is currently progressing quite well in the construction of tankers and barges.

As of April 1, 1976 the following ships were under contract at Seatrain:

Quantity	Type	Propulsion	Size
3	Tanker	Steam Turbine	225,000 dwt
4	Barge		(unknown)

A brief description of the piping design, fabrication, and installation activities at Seatrain is given in the following paragraphs. This description is current to April .1, 1976.

D.2.2 DESIGN

Seatrain is currently relying upon design agents for most of its basic and detailed design work. A small, competent, design and engineering group makes any design changes that may be required during construction. Very little information was available on design practices, since most design documents were prepared by the design agent. It was noted that the quality of work received from the design agent and that done at Seatrain appeared to be good.

D.2.3 FABRICATION.

The-pipe shop at Seatrain is adequate in size and is well laid out for processing commercial ship piping. The bulk of piping fabricated is cargo and ballast piping, since piping under 2-inches (I P.S.) in size is field run, and main steam piping is subcontracted. Standard lengths of raw pipe are delivered to the shop entrance where they are

cut with propane torches to design lengths and end-prepared for welding as required. Pipe up to a diameter of 6 inches requiring bending is processed on a 6-inch Wallace bender. Other processing is accomplished on power hack saws, radial cut-off saws, drill presses, jigs and fixtures for fabrication and welding, and small hand tools for chipping and grinding.

Cargo piping was being processed during the tour, and standard fabrication techniques for performing this work were observed. The fit-up was good and the welding was excellent. The general flow of material through the shop was orderly and efficient. Normally, only ferrous piping is processed in the pipe shop; however, skilled coppersmiths are available to handle any non-ferrous piping rewired. Heater coils were joined using socket welds. It was noted that all pickling and galvanizing work required at any stage of the fabrication process must be performed by outside contractors. Also noted was that all finished pipe was properly capped prior to removal to storage or the ship.

Work is planned and scheduled in the usual manner of work packages. It was indicated that large assemblies and modules are not generally used due to limited lifting capacity. Gage boards are normally piped up aboard ship.

#### D.2.4 INSTALLATION

A tour of the machinery space on a 225,000 dwt tanker was conducted to observe installation practices. While there was no work on pipe in progress at the time, observation of the work completed revealed that the pipe installed was well run and hung with standard hangers. Pipe configurations were well-aligned and compactly arranged. Welded joints were above average. No innovative or unusual techniques were observed. Some problems with the quality of cast valves were noted.

#### C.2.5 ACKNOWLEDGEMENTS

For their kind assistance in providing us with an interesting and informative tour of Seatrain Shipbuilding Corporation we wish to thank the following people:

J. Serrie - President  
G. Vought - Director of Planning  
T. Farley - Engineer  
M. Matty - Engineer

SECTION D.3  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
QUINCY SHIPBUILDING DIVISION  
OF  
GENERAL DYNAMICS CORPORATION

D.3.1 INTRODUCTION

A tour of Quincy Shipbuilding Division located in Quincy, Massachusetts, was conducted on October 10, 1975 for the purpose of collecting pipe technology data. Additional data was collected via correspondence and telephone interviews.

In general, the piping process at Quincy is basically conventional with some novel cost-effective methods used in the design area. Quincy's LNG program appears to be progressing quite well. As of April-1 1976, the following ships were under contract at Quincy:

Quantity	Type	Propulsion.	Size
8	LNG	Steam Turbine	63,600 dwt .

A brief description of the piping design, fabrication, and installation activities at Quincy is given in the following paragraphs. This description is current to April. 1, 1976.

D.3.2 DESIGN

The preparation of system diagrams and material estimates follows the same pattern as for other shipyards surveyed. Computer programs are used for pipe stress and heat balance calculations.

A computer interference control program was tested but did not prove to be highly successful. Composites are developed after arrangement drawings are made for a given area and are used as interference check drawings only. The preparation of the arrangement drawings is greatly facilitated by the use of structural backgrounds prepared by the Autokon I System. It was noted that numerous drawings are produced by this system for the various activities throughout the yard.

Pipe details are not prepared by design; they are prepared entirely by the shop. This system appears to work well.



Problems of particular concern Quincy are material procurement delays, and the present U. S. Coast Guard approval policies. Approval delays have been very disruptive to their LNG program.

Design personnel expressed interest in the Japanese Hicass-P Pipe System, marketed by Hitachi Zosen. This system builds a data base from ship structural data and prints out pipe piece drawings, detailed arrangements, joint identification, and positioning. The Task S-4 project team was asked to investigate further.

### D.3.3 FABRICATION

As noted previously, the pipe shop prepares the pipe details from the arrangement drawings. This requires that arrangement drawings be made available to the shop earlier than otherwise would be required, but this does not appear to be a problem, since sufficient lead time is available on the LNG program. The pipe shop was quite impressive. The shop is located in close proximity to all material required for fabrication, thus eliminating lost time in this area. Work flow through the shop is essentially straight-line and appeared to be efficient. A special area at the end of the production line is utilized for subassembly work.

Cut-off is accomplished via band saws, torches, and abrasive saws. A plasma cut-off torch has been ordered. For end-preparation, the pipe shop has ordered an H&M lathe which will handle pipe up to 24 inches (I.P.S.) in diameter. This machine will handle all grades and schedules of pipe and it was stated that its primary use would be for schedule 10 stainless steel pipe.

Bending is done on conventional machines to a radius of 5D. The shop has a coil bender for heater coils. Fabrication is done at work stations, where material is delivered in accordance with job packages.

All welded joints appeared good. The automatic welding was exceptionally good, due in no small measure to the expertise and skill of the operator. Pipe shop personnel were also quite pleased with their new orbital welding equipment that was being used to weld stainless steel pipe. The equipment is manufactured by Hi-Pulse Diametrics, Inc. of North Hollywood, California. Square butt joints on schedule 10 stainless steel pipe were done on this equipment and appeared to be of exceptionally high quality. The shop was also pleased with their Pines Roto-Form bender.

Pipe is cleaned using both soda and an acid rinse; all fabricated piping is cleaned prior to shipping. Pipe is tagged and placed on pallets for transportation to storage or to the ship.

A covered area outside the pipe shop is used to pre-fabricate modules. An entire pump room, pre-mounted on a foundation and ready for installation, was noted during the tour.

#### D.3.4 INSTALLATION

A ship tour was not conducted. However, a general discussion of the installation activities indicated that no special techniques are utilized. No problems of making ship joints on cryogenic piping were anticipated. Since backir rings would be used to eliminate the need for purging.

#### D.3.5 ACKNOWLEDGMENTS

we thank the following people who were very helpful in assisting us in the tour of Quincy:

L. H. Holt III - Director of Engineering  
J. D. Kelly - Manager, Design  
W. E. Pray - Chief, Marine Design  
J. E. Craft - Chief, Marine Engineeririg  
D. Rivard - Supervisor, Pipefitters

Also, we wish to thank W. E. Pray. for providing additional information on Quincy and ~~for~~ **serving on the** Task S-4 Advisory Council.

SECTION D.4  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
SUN SHIPBUILDING AND DRY DOCK COMPANY

D.4.1 INTRODUCTION

A tour of Sun Shipbuilding and Dry Dock Company, located in Chester, Pennsylvania, was conducted on October 9, 1975 for the purpose of collecting pipe technology data. Additional data was collected via telephone interviews.

In general, Sun appears to be a rather progressive yard, especially in the area of piping engineering and design. Most noteworthy is the willingness "to try relatively novel methods." Sun is a flexible yard capable of handling construction of several types of vessels simultaneously.

As of April 1, 1976 the following ships were under contract at Sun:

Quantity	Type	Propulsion	Size
1	RO/RO	Steam Turbine	17,300 dwt
2	LNG	Steam Turbine	65,350 dwt
2	Tanker	Steam Turbine	124,000 dwt

A brief description of the piping design, fabrication, and installation activities is given in the following paragraphs. This description is current to April 1, 1976.

D.4.2 DESIGN

The preparation of system diagrams and material estimates at Sun is basically the same as for other shipyards surveyed. Computer programs are used for pipe stress and heat balance, and in some cases for pressure loss calculations. It was indicated that fairly close contact was maintained with the trades during original design and as fabrication and installation work progressed.

Sun does not generally use interference control drawings. Interferences are normally worked out by individual designers as the design of a particular area progresses. It was noted however, that a computer interference control program is used to some extent on new design work. The use of a scale model to work out the detailed design of an unusual ship design was described in some detail. The ship is a triple-screw RO/RO vessel designed for a 35-knot cruising speed. Because of the high level of congestion in the machinery spaces, a large,

highly-detailed scale model was constructed from preliminary drawings; the model included all machinery, piping, ventilation, wireways, and electrical equipment. The model required approximately 5500 man-hours to construct, but had already paid for itself in the number of pipe joints eliminated. After all design data has been lifted from the model, the model will be placed near the installation activities for ready-reference.

Perhaps the most notable innovation at Sun in the piping design area is the use of isometric arrangement drawings in areas of high congestion. These drawings are exceptionally easy to read and apparently are not much more difficult to produce than standard orthographic arrangement drawings. Drawings are kept short so that they are easy to handle. This proves to be a great help to the fabrication and installation activities when working in congested areas. Also noted was the use of the same type of isometric drawing for stress analysis.

Another item of interest was the use of ASTM A587 material in lieu of A53 wherever allowed by U. S. Coast Guard regulations. Sun appears to have a close working relationship with the U. S. Coast Guard and feels that, in general, there are no serious problems.

The development of pipe details from the arrangement drawings is basically a manual process at Sun. Design prepares the details and submits them directly to the pipe shop. Some template ends are used to facilitate installation at tight points, much the same as at other shipyards surveyed. Three inches are generally allowed for this purpose. However, pipe details are mostly designed neat to a tolerance of 1/16 inch.

#### D.4.3 FABRICATION

In general, the pipe shops at Sun are adequate. Pipe enters the pipe shops from a covered storage area and proceeds through the cut-off area to the bending area. Most pipe is bent to a radius of 5D. Hot bending is done for pipe over 12 inches (I.P.S.) in diameter. Some interest in 2D bending was expressed.

The highly-skilled pipe-fitters turn out good work without the use of sophisticated equipment. Manual, semi-automatic; and automatic welding is used, depending upon the application. Mitered elbows are used extensively to cut down on copper pipe waste and to eliminate work stoppages due to lack of elbows. Pipe hangers are made in the shop;

gaskets and pipe caps are purchased. Also noted was the extensive use of flanged joints similar to those of the Van Stone type. This type of joint is made by forming a lip on the type and placing a loose flange behind the lip. This joint allows for rotation of the flange during fit-up, thus facilitating installation of large pipe.

#### D.4.4 INSTALLATION

A ship tour was not conducted. However, a general discussion of installation techniques indicated that no special techniques are utilized.

#### D.4.5 ACKNOWLEDGEMENTS

we wish to thank the following people who were quite helpful in providing information during the tour of sun Shipbuilding. and Dry Dock Company:

- F. Hartman - General Superintendent
- R. Lamb - Chief, Machinery Technical
- J. Wittmeyer - Chief, Machinery Technical  
(replaced R. Lamb since tour was conducted)
- J. Matthews - Director
- J. Drye - General Cargo Production Group Engineer
- C. Allen - Chief Draftsman, Machinery and Piping,  
Machinery Engineering Division
- A. Adams - Copper Shop
- F. Me-trick - Pipe Shop Foreman

SECTION D.5  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
BETHLEHEM STEEL CORPORATION  
SPARROWS POINT YARD

D.5.1 INTRODUCTION

A tour of the Sparrows Point Yard of Bethlehem' Steel Corporation, located in Sparrows Point, Maryland, was conducted on October 18, 1975 for the purpose of collecting pipe technology data. Additional data was collected via correspondence and telephone interviews.

In general the piping process at Bethlehem - Sparrows Point is currently geared to the production of large tankers. Piping-design, fabrication, and installation is accomplished in a basically conventional environment with good quality work prevailing throughout the process.

As of April 1, 1975 the following ships were under contract at Bethlehem - Sparrows Point:

Quantity	Type	Propulsion	Size
2	Tanker	Steam Turbine	255,000 dwt
2	Tanker	Steam Turbine	265,000 dwt

A brief description of the piping design, fabrication, and installation activities at Bethlehem - Sparrows Point is given in the following paragraphs. This description is current to April 1, 1976.

D.5.2 DESIGN

The preparation of system diagrams and material estimates follows the same pattern as for other shipyards surveyed. Most calculations are performed manually-by a small, but highly competent, group of engineers.

Composites are drawn for the machinery spaces. Each composite is then divided into work group modules, the concept being to group out all work by modules rather than by system. All, systems within the confines of a given module: are worked as a group.

Pipe details are prepared by both design and shop personnel; pipe details for-the main steam system-are handled

by design while those for most other systems are handled by-a special pipe detail group in the shop. Pipe details are drawn on a special form and contain all information required for fabrication. The quality of the manually-prepared details appeared-to be excellent.

A steel flange design has been developed by Bethlehem - Sparrows Point which eliminates the need for bronze flanges on copper and copper-nickel pipe. The flange is machined at the face to allow for the buildup of a monel cladding, which is then machined to form part of the flange face. The monel cladding acts as a buffer zone between the copper-nickel and steel. It was stated that the savings of steel versus. bronze flanges significantly outweighs the added labor costs involved in this process.

#### D.5.3 FABRICATION

As noted above, most pipe details are prepared by pipe shop personnel. Material is drawn from local storage areas in accordance with information given on the details. Pipe details and required material are passed along to various work stations until all shop work has been completed. Completed pipe assemblies are then palletized and sent to the installation areas. Much of the copper pipe work is handled in a separate copper shop.

Pipe shop facilities at Bethlehem - Sparrows Point are adequate for the present work load, although it was noted that there was insufficient storage space for material and finished pipe. (This is a problem shared by many ship-yards today.) Skill levels appeared to be high, which more than made up for any lack of sophisticated equipment.

One item of particular interest was the use of a special steel pallet shaped much like a baby cradle. This design appears to be superior to conventional flat pallets, since pipe assemblies tend to stay in the cradle without the need for straps. Lifting lugs were attached so that cradles could be moved easily by crane.

#### D.5.4 INSTALLATION

A ship tour was not conducted. However, discussions with installation personnel indicated that installation of piping is done in a basically conventional manner.

#### D.5.5 ACKNOWLEDGEMENTS

We wish to thank the following people who made our tour of Bethlehem - Sparrows Point a significant. contribution to the Task S-4 effort.

W. Brayton - Assistant Production Manager  
F. Wilfong - Project Engineer  
H. Bauersfeld - Chief Machinery Draftsman  
J. Dougherty - Systems Engineer  
C. Peters - Foreman of Pipe Shop

Also, we wish to thank A. Nehrenz - Piping Engineer who provided additional information on Bethlehem - Sparrows Point and



SECTION D. 6  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
NEWPORT NEWS SHIPBUILDING

D.6.1 INTRODUCTION

Various tours and surveys of Newport News Shipbuilding, located in Newport News, Virginia, were conducted from June 1975 through March 1976 for the purpose of studying pipe technology. Studies of supporting technology were also made.

Newport News Shipbuilding is currently heavily involved in the construction of Navy carriers and submarines, and, as a major expansion program nearing completion, the yard is also actively involved in the construction of commercial ships.

As of April 1, 1976 the following ships were under contract at Newport News Shipbuilding:

<u>Quantity</u>	<u>Type</u>	<u>Propulsion</u>	<u>Size</u>
3	T a n k e r	Steam Turbine	390,770 dwt
3	LNG	Steam Turbine	63,460 dwt
1	Multi-purpose Carrier (CVN70)		
1	Attack Carrier (CVN69)		
3	Submarine (SSN-587-9)		
3	Submarine (SSN-591,3,5)		
3	DLGN (DLGN 37, 38, 40) -		

A brief description of the piping design, fabrication, and installation activities at Newport News Shipbuilding is given in the following paragraphs. This description is current to April 1, 1976.

D.6.2 DESIGN PROCESS

System diagrams are first prepared by piping designers using information provided in the ship specifications, contract drawings, and contract guidance drawings. Pipe sizes and flow data are prepared by a designated group of engineers and are added to the system diagrams. Material estimates are made using tile system diagrams and, in some cases, preliminary piping schemes. Material estimates are updated as necessary to reflect-detail design. A material ordering schedule is prepared and purchase orders are placed to secure vendor

Once an outfitting schedule is established and structural drawings become available, the detailed arrangements of piping systems are prepared. Interference control is accomplished almost entirely through the use of space composites. Mockups are used in certain areas of Navy ships, but, in general, have not proven to be as successful as space composites in controlling interferences. After interference-free paths have been established on the composites for all systems in a given space, information is lifted off the composites and individual system arrangement drawings are prepared. Supplemental documents are also prepared in the form of general notes, standard details, and standard shipyard procedures. The arrangement drawings and supplemental documents together provide all of the information required by the ship activities to install the piping systems. Information required by the shop activities to fabricate pipe assemblies is provided on separate pipe detail document.

Information required to prepare pipe details is taken directly off the arrangement drawings and is input to the Computer Aided Piping Design and Manufacturing System (CAPDAMS). The output of this process is a computer-printed pipe detail including all information required to fabricate a given piece of pipe. For some contracts hand-drawn details are still prepared. Pipe is normally detailed down to a size of 2 inches (I.P.S.) in diameter.

#### D.6.3 FABRICATION

GENERAL -Piping fabrication-at Newport News Shipbuilding is accomplished in one of three shops: the main pipe shop fabricates the bulk of ferrous piping; the copper pipe shop fabricates copper and copper-nickel piping; and, the nuclear pipe shop fabricates and tests all nuclear piping. Only the main pipe shop and the copper pipe shop are presently involved in the piping fabrication process for commercial ships. The processes in these two shops are basically the same.

Shop work is planned and then scheduled to be fabricated 8 to 10 weeks prior to the scheduled installation aboard ship. Shop planners provide shop work packages to comply with schedules, and shop material men order out the pipe and components for the packages. Pipe is normally cut to length in the pipe storage area and is delivered to the shop for fabrication.

The CAPDAMS pipe details are the primary working documents used to fabricate piping. Each detail gives a computer-drawn picture of the pipe and fittings to be fabricated, and also provides all material and fabrication data. Fabrication

parameters include lengths of pipe, bend angles, rotation angles, and types of joining techniques to be used. These parameters are arranged in order of execution and are given in a form directly usable by the bending machine operator. This system has allowed the use of less-skilled people to bend and fabricate pipe, and, in general, has proven to be a very workable and cost-effective system for the pipe shops.

For bending of pipe in accordance with hand-drawn details, the bending machine operator must possess the knowledge and skill required to make necessary layouts and calculations.

COPPER PIPE SHOP - In the copper shop, material for non-ferrous pipe work packages is assembled by the material men and is provided to the mechanic. Pipe requiring bending is grouped according to size to minimize machine set up. Copper; copper-nickel, and nickel-copper pipe up to a size of 6 inches (I.P.S.) in diameter is processed on booster benders, which permit bending to a radius of  $2D$ ; pipe from 6 inches (I.P.S.) to 14 inches (I.P.S.) must be bent to a radius of  $5D$  on standard bending machines in the steel pipe shop. Non-ferrous pipe is generally annealed in the area of  $2D$  bends prior to bending using hand-held torches. A water-soluble lubricant is used on all bending machine mandrels to facilitate pipe cleaning after fabrication.

Bent pipe requiring no further fabrication is cleaned as required, tagged, capped, and shipped to either a designated storage area or directly to a material stop on the ship. Pipe requiring further fabrication is tagged and sent to the appropriate work station. Fabrication activities at the various work stations include extrusion of bosses, and brazing or welding of fittings to the pipe.

End-preparation equipment includes power band saws, lathes, and boring mills. Welding equipment includes both TIG manual and semi-automatic units. Cleaning is done in hot water rinse tanks. Handling equipment includes overhead floor-operated cranes, post cranes, and mobile hand carts.

Pipe hangers are made in a shop adjacent to the copper shop. Non-standard or non-stocked gaskets can be made in the copper shop as required. Any special wooden templates that may be required can also be made in the copper shop.

STEEL PIPE SHOP - Job packages and material handling are done in much the same manner as in the copper shop. End-preparation of pipe is done on Landis machines for standard bevels. Fittings requiring machining are processed on either a lathe or a boring mill.

Since the steel pipe bending machines do not have booster capabilities, pipe processed on these machines - 14 inches (I.P.S.) in diameter and below - must be bent to a radius of 5D. No hot bending is done. A spiral bender is provided for making heater coils.

Stress relieving-is accomplished by induction heating as required. Cleaning is done-with wire brushes, acid, soda, or hot water, depending on the application. Welding equipment includes manual stick electrode and TIG semi-automatic equipment. Chipping and grinding equipment are provided in fabrication area. Additional equipment includes: band saws, and a Stephen burning machine for cut-off, branch burning, ar beveling; equipment for hot-forming pipe reducers; various air-powered cutters and grinders; and equipment for performing air-and hydro-testing.

The present trend is toward more subassembly work to be completed in the pipe shops. Gageboards, manifolds, and other small subassemblies are being prefabricated but very few large subassemblies are being prefabricated. As the level of commercial ship production at Newport News Shipbuilding increases, it is anticipated that prefabrication of large subassemblies in the shops will be increased.

#### D.6.4 INSTALLATION

Structural subassemblies of LNG tankers are pre-outfitted to the fullest extent possible prior to erection. The Autokon system is utilized to pre-cut as many piping penetrations as possible during the plate burning phase of structural work, thus minimizing field cuts. Where possible, a straight pipe run is made up in a length equal to a structural subassembly length and such that any expansion loop is located at the end of the structural subassembly. The pipe run is then passed through the pre-cut holes and hung in place. This method greatly reduces the number of joints that have to be made within the confined areas of the structural subassembly. Pipe hangers at the ends of piping runs are left loose to facilitate alignment as structural subassemblies are joined. Pipe below 2 inches (I.P.S.) in diameter is field bent in accordance with sketches prepared by planners or mechanics aboard-ship.

#### D.6.5 ACKNOWLEDGEMENTS

The following people were instrumental in preparing documentation on the piping technology at Newport News Shipbuilding:

E. E. Stephenson  
J. D. Snyder  
F. L. Basnight  
L. E. Williams, Jr.  
R. Davis  
J. Edwards  
L. B. Weaber  
R. S. Oglesby

. SHIPYARDS  
-GULF COAST-

SECTION D. 7  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
INGALLS SHIPBUILDING DIVISION  
OF  
LITTON INDUSTRIES , INC.

D.7.1 INTRODUCTION

A tour of the Ingalls Shipbuilding Division (West Bank), located in Pascagoula, Mississippi, was conducted on September 30, 1975 for the purpose of collecting pipe - technology data. Additional data was collected via telephone i n t e r v i e w s .

In general; Ingalls-West specializes in the efficient series production-of multiple ship contracts. The piping design, fabrication, and installation activities are all geared to this type of ship production. \_ Although Ingalls-West is currently involved only in Navy work, their construction techniques are applicable to commercial work.

As of April 1, 1976, the following ships were under contract at Ingalls-West:

Quantity	Type	Propulsion	Size
29	Destroyers (DD-963-92)		
5	Amphibious Assault (LHA-1-5)		

A brief description of the piping design, fabrication, and installation activities at Ingalls-West is given in the following paragraphs. This description has been updated as necessary to April 1, 1976.

D.7.2 DESIGN

The piping design process at Ingalls-West is quite similar to that at Newport News Shipbuilding. System diagrams are first prepared. using information provided in the ship specifications, contract drawings, and contract guidance drawings: Pipe sizes and flow data are determined by the engineers and added. to the system diagrams. Preliminary material estimates are prepared from the diagrams and later updated as the detail design progresses. A material ordering schedule is prepared and purchase orders are placed to secure vendor supplied items.

The detailed design of piping systems is accomplished using space composites as the primary design tool. It was noted, however, that a highly-detailed scale model was used during the design of the LHA ships. This model was built to a scale of 3/4 inch = 1 foot and included machinery and most ventilation, piping, and wireways. The model was made readily accessible to the piping designers, who then prepared detailed space composites from the information portrayed in the model. After all composites were developed, the model was no longer used as a design tool. The LHA and DD963 Class ships being built at Ingalls-West are outfitted by modular subassemblies. This requires that the ship be divided into modules and each module be divided into deck areas. For each deck area a composite is prepared showing all machinery, ventilation, and piping over 1-1/2 inches in diameter. Much effort goes into developing and maintaining the composites so that interferences are eliminated in the design stage.

The preparation of individual arrangement-drawings for a given deck area follows the completion of the composite for that area. Each designer first draws a structural background to the same scale as the composite, and then traces a system off the composite onto the structural background. Dimensions are scaled off the composites and added to the arrangement drawing along with pipe and fitting numbers, group numbers, hole cut data, and general notes. The grouping function of the design activity takes data from the various arrangement drawings and prepares computer printouts for each group and assigns group start and completion dates.

The preparation of pipe details is primarily a manual activity where the designer takes information off the arrangement drawing and draws a simple sketch for each pipe detail. It should be noted, however, that a system similar to the Newport News CAPDAM System was developed and used at Ingalls-West until recently, when it was abandoned. Although pipe detail sketches are not drawn manually, computer printouts are still provided to the shops which give for each detail the pipe sizes and lengths required; tangent lengths, bend angles, rotation angles, and flange orientation data. Pipes to be ship-fitted to length are so marked on the sketch and an allowance of 4 inches is provided at the joint to be fitted.

After a given arrangement drawing and related pipe details are completed, check prints are made and submitted to the ship trades for review. The various trades do not generally participate in the preliminary design of a ship, and,



for the most part, depend heavily upon the design departments for the accuracy of the detail design information.

Throughout the piping design process no special drafting techniques are used. Drafting quality was generally good and drawings were legible. It was stated, however, that a number of LHA drawings had to be redrawn because of dirt accumulation on the-plastic drafting film.

#### D.7.3 FABRICATION:

Ingalls-West has large outside storage areas for both raw pipe and finished pipe assemblies. Raw pipe enters one end of the pipe shop and is cut to length with a pipe . cutoff saw or a plasma cutoff. machine. Pipe detailing data is placed in plastic bags which are. taped to the cut pipe - sections to be processed. The pipe shop is equipped with booster benders with a capacity up to 16 inches (I.P.S.) in diameter. However, no 2D bending is used. After bending, pipes are routed out of a side door of the shop for steam cleaning to remove grease.

Pipe welding appears to be conventional, except for the TIG welding versus brazing of copper pipe. Automatic welding of sleeve penetrations was also noted. Soda tanks adjacent to work benches facilitate the cleaning of brazed joints. All work is routed to individual work stations by material men in accordance with the production control schedules. Welded pipe is first tack-welded by the assembly man and then finish-welded at a separate work station.

One item of particular interest is a special hydraulic device for extruding bosses on copper nickel and aluminum pipe up to a wall thickness of .250 inches. An elliptical-shaped hole is first burned at the location of a boss. The pipe is then clamped in a jig and an upper annular-shaped die is placed over the hole and clamped in place. The boss is formed by pulling progressively larger dies through the :hole and the upper die. Although the device is designed so that matched pairs of upper and lower dies are used in progressively larger sizes, shop personnel indicated that only the final. size of. the upper die is generally required to achieve acceptable results. Turning rolls are used for annealing, and sprayer are used for quenching. - - - -

Although a large amount of finished pipe was noted in outside storage areas, the shop was working two full shifts to keep up with the work load. All jobs had target completion

dates assigned by production control to measure productivity and to establish shop manning levels.

As noted earlier there is little participation of the shop and ship trades in the initial design of piping systems. However, after the lead ship of a multiple-ship contract is substantially complete, production control examines the various piping systems for the purpose of eliminating joint and grouping individual pipes into larger pipe subassemblies on the follow ships. Thus, the number of ship joints is significantly reduced on follow ships.

#### D.7.4        INSTALLATION

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The most impressive feature of the Ingalls-West yard-- is the system of pre-outfitting modular subassemblies - a system which is unique among U. S. shipyards. Modular subassemblies consist of all structure between two designated transverse sections through the ship from the keel to main deck. These modular subassemblies are almost completely pre-outfitted before being joined to form the complete ship. Pre-outfitting includes machinery, pumps, piping, ductwork, and local wireways. After modular subassemblies are completed they are moved, along with staging, progressively closer to the launch site using motorized dollies on tracks. Once all modular subassemblies are joined, the entire ship is moved via the dolly/track system into a floating dry dock for launching. The fit-up of piping during the joining process is facilitated by leaving hangers loose at pipe ends. Deck houses are also pre-outfitted in much the same manner.

#### D.7.5        ACKNOWLEDGEMENTS

For their courteous cooperation in conducting a tour of Ingalls-West and in providing helpful information, we wish to thank the following people:

F. E. McConnell  
J. Green  
B. D. Williamson  
C. G. Emerson  
O. V. Clapper  
J. W. Valleck  
J. Reeves  
C. A. Lacy  
C. B. Oden, Jr.

SECTION D. 8  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
AVONDALE SHIPYARDS, INC.

D.8.1 INTRODUCTION

A tour of Avondale Shipyards, Inc., located at New Orleans, Louisiana, was conducted on October 1, and 2, 1975 for the purpose of collecting pipe technology data. Additional data was collected via correspondence and telephone interviews. In general, Avondale appears to be a close-knit organization which has been successful in building a wide-range-of different ship types. as well as drill rigs. Their piping process is one of the most efficient in the U . S . ship building industry

As of April 1, 1976, the following ships were under contract at Avondale:

<u>Quantity</u>	Type	Propulsion	Size
6	Tanker	Steam Turbine	165,000 dw
3	LNG	Steam Turbine	63,460 d
3	Product Carrier	Steam Turbine	56,000 dwt
4	Drill Ship		
5	Semi-submersible	-	

A brief description of the piping design, fabrication, and installation activities at Avondale is given in the following paragraphs. This description has been updated as necessary to April 1, 1975.

D.8.2 DESIGN

The preparation of system diagrams and the process of making preliminary material estimates is basically the same as for other shipyards-surveyed. Although computer programs are used for stress and flexibility analysis, no other computer-aided design tools are used. Avondale relies heavily upon a highly-skilled composite group to work out machinery and piping layouts to such a level of detail and accuracy that very few revisions are ever necessary to correct shipboard interferences. Composites are drawn to a scale of 3/4 or 1-inch = 1 foot on a background reproduced from a working structural drawing. Normally, plan views and transverse sections are all that is required to portray an area; very few elevations are used. Because of the high degree of

accuracy obtainable with the scales used, layouts are considered to be final and, in general, no changes are permitted unless cleared by the composite group.

Arrangement drawings are prepared by first having the composite group highlight a given system on a blue-line print of the composite. The print and a sepia reproducible of the same composite are then submitted to a draftsman who then goes over the sepia to darken up all linework related to the system highlighted on the print. The area of the sepia depicting the system is then cut out and taped onto plastic drawing film, which, after the addition of a title block and pertinent design information, becomes a complete arrangement drawing. Pertinent design information includes dimensioning, general notes, material lists, and -pipe detail identification numbers.

Pipe details are generally made neat; that is, no ship fit-up allowance is given on most details. Fittings or flanges at especially tight joints are sometimes designated on the pipe details to be left loose. It was stated that approximately 90 percent of all pipe details for a given ship are installed under this method with no fit-up problems during installation; the remaining 10 percent generally require only minor rework to fit properly. Design, fabrication, and installation personnel all agree that this is a very-workable and cost-saving method requiring little additional work in the field. Savings in material, fabrication, and installation labor appear to be significant. The lack of field welds noted on the ship verified this.

Avondale does not consider the use of models to be a workable, cost-effective design aid. Cost is considered to be prohibitive, especially since the end product must still be portrayed in some graphical form.

A close working relationship between design and the production trades facilitates the resolution of problems related to fabrication and installation during the design phase. Problems occurring during fabrication or installation are often worked out on the spot through mutual understanding and agreement.

Pipe details are drawn freehand on computer-printed forms, which contain all material and fabrication information required to make up the details. Input data for such information is taken from the arrangement drawings.

### D.8.3 FABRICATION

Raw pipe enters the pipe shop from an outdoor storage area. Usually one bay is utilized for copper and copper-nickel pipe, and another bay is used for steel pipe. Pipe is cut to length in accordance with a job order and is sent to the fabrication or bending areas. Bends are made on 2D and 5D booster benders. End preparation is done with torches. A Steffan numerical control plasma arc cutting machine is used for stainless steel- and copper-nickel pipe. This machine also makes cuts for branches, saddles, and miters.

Very small amounts of easy-bend lubrication are used; pipes are not cleaned-after bending or brazing but. are generally -cleaned-just prior to coating. Plastic pipe caps are used after fabrication..is complete *but. did-not* appear to hold up well in the field.

Avondale manufacturers most of its own gaskets in a special area of the pipe shop. Gaskets are manufactured during slack periods in the pipe-shop in order to fully utilize shop personnel at all times. The gaskets are punched out with a special hydraulic press fitted with interchangeable dies. Flexitalic and high-pressure gaskets are purchased.

Steel pipe is normally cut freehand with a propane torch and is then end-prepared with grinders. Welding is done manually in the pipe shop. However, semi-automatic welding of pipe is done by the welding department. Backing rings are used for steel, and consumable inserts are used for copper-nickel.

Pipe fabrication is accomplished by highly-skilled pipe fitters. Prepared pipe and all fittings required to complete a job order are palletized and moved to the pipe . fitter work stations by material men. Fabricated pipe requiring welding is tack--welded by the pipe fitters and then sent to the welders for final welding. After welding, pipe is sent to an X-ray booth at the end of the shop. After X-ray, pipe is strapped to pallets and sent to storage.

One item of particular interest is the use of flared joints in lieu of couplings for copper and copper-  
- nickel pipe. This method requires only half the number of joints required by the use of couplings or sleeves. The method is used extensively for both shop and ship joints and appears to be quite cost-effective.

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Avondale is presently fabricating and installing all cryogenic piping on their LNG tankers. For argon purging of joints during welding, a special blank-off rig is utilized to confine argon to the immediate vicinity of the welding process, thus conserving argon. Although the shop welding of cryogenic piping is going smoothly, the pipe shop personnel were concerned over the field-welding problems. Also, they did not find that TIG welding offered any savings over brazing.

In general, the pipe shop appeared to be adequate and the workmanship good. Although work consists mostly of detailed pipe, some smaller work (such as manifolds) is also done. The shop is hoping to work with design to make greater use of modular subassemblies. Shop improvements are under study and it appears that improvements will be in the area of greater automation.

#### D.8.4. INSTALLATION

A tour of an LNG tanker-under construction at Avondale was conducted. In general, there were no problems of congestion. In fact, the large machinery spaces required that special rigging be used to handle the large piping. Heater coils, mounted on the platens, appeared to be of good arrangement and workmanship. Piping not fitted up on a platen is left loose. Standard hangers are used in most cases. It was noted that 3 inch x 4 inch (or larger) angle bar hangers were used to support both piping and ventilation ductwork. This is an innovative method which has been approved by the regulatory bodies.

Several pumps, valves, and fittings were not yet installed - Avondale suffers from the same problem of material availability as other shipyards. Avondale does not generally subcontract work. However, it was noted that containment on the LNG tankers is being installed by an outside contractor.

Scheduling of both the shop and ship activities is accomplished by production control. As erection dates and fabrication schedules are released, the shop planners work out individual job orders for the pipe shop. The production engineers assign target manhours for all jobs and it appeared that budget manhours equaled actual manhours in most cases. It was noted, however, that additional manhours for ship work had been requested for the underestimated rigging and handling of large piping in the machinery spaces.

As material becomes available for a particular job it is packaged and sent to the shop by job number. All finished details are metal-tagged. Heavy tags are used for this purpose and are made by hand using punches. Pipe ready for installation aboard ship is brought to the ship on pallets. This appeared to be a good method of handling pipe in job orders. The system is simple, requires few people, and seems to satisfy both the fabrication and installation activities.

#### D.8.5 ACKNOWLEDGEMENTS

For their kind assistance in conducting a tour of Avondale and in providing helpful information, we wish to thank the following people:

C. M o r r i s  
L. T i l l e y  
L. S e g f u  
M. Jiminez  
P. Beertson  
R. Roux  
R. Duhon

Also, we wish to thank R. Duhon, who provided additional information on Avondale and who has served on the Task S-4 Advisory Council.

SHIPYARDS  
-WEST COAST-



SECTION D.9  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
NATIONAL STEEL-AND SHIPBUILDING COMPANY

D.9.1 INTRODUCTION

A tour of National Steel and Shipbuilding Company (NASSCO), located at San Diego, California, was conducted on February 4, 1976 for the purpose of collecting pipe technology data. Additional data was collected via telephone interviews.

In general, NASSCO is one of the most progressive shipyards in the--country, especially in the areas of design and production. control. They are presently involved in both commercial and Navy work and appear to handle both with a high degree of efficiency.

As of April 1, 1976, the following ships were under contract at NASSCO:

	Quantity	Type	Propulsion	Size
1	2	Tanker	Steam Turbine	53,725 dwt
	10	Tanker	Steam Turbine	89,700 dwt
	2	Tanker	Steam Turbine	150,000 dwt
	2	Tanker	Steam Turbine	190,000 dwt
	1	Replenishment Oiler (AOR-7)	--	
	1	Destroyer Tender (AD-41)		

A brief description of the piping design, fabrication, and installation activities at NASSCO is given in the following paragraphs. This description has been updated as necessary to April 1, 1976.

D.9.2 DESIGN

NASSCO places great emphasis on the accuracy and completeness of their system diagrams. A System Design Memo is prepared prior to the preparation of a particular system diagram. This System Design Memo contains the title of the system, a listing of the objectives of the system, a listing of the required approval authorities, a listing of applicable references, the results of engineering calculations and a sketch of the system to be depicted on the diagram, specific instructions to the design activity on further action to be

taken upon receipt of the completed System Design Memo, a listing of interconnecting diagrams, and any special notes or other related descriptive matter. In addition to the System Design Memo and diagrams, the engineering staff prepares a Specifications Design Parameters document which very clearly defines each piece of equipment which must be bought for each system. This document contains the name of the equipment required, a brief description of the equipment, a listing of the technical details of the equipment, all vendor information that is required, a listing of equipment interfaces, and any additional information that may be required to effect proper procurement of the equipment. Thus, the System Design Memo, the system diagram, and the Specification Design Parameters document, all serve to clearly define and portray a given system and its components. The diagrams also serve as approval documents.

NASSCO relies on the space Composite for its interference control method. Machinery space composites are generally handled by one person. The techniques used to prepare composites differ somewhat from those observed at other shipyards. A blue line print of the background structure for a particular composite area (drawn to a scale of 3/8-inch = 1 foot) is first obtained and covered with a sheet of tracing vellum to form what is called a "composite worksheet". An order of priority is assigned to the various systems that go into the composite area, and then the systems are drawn on the worksheet in the order of priority by competent designers, each of whom must clear his system with all other systems already on the worksheet. When all systems have been cleared on the worksheet, a final composite is prepared and issued as a finished reference document for any subsequent changes. Finished arrangement drawings are prepared by the designers and issued only after the composite is finalized. NASSCO does not use models or mockups. Also, pipe details are prepared by the fabricating activity.

NASSCO uses several computer programs. Included are the MLQ and SLQ programs for pressure loss and pipe sizing, AUTOFLEX and TRIFLEX for stress; and proprietary heat balance and ventilation programs. Also, a proprietary cargo system unloading time program (PROS) is used.

The most significant problem area noted was the lack of standardization of marine components such as pumps, valves, and fittings. This problem often disrupts fabrication procedures when procured components differ from those upon which detail design was based. Also noted was the poor quality of vendor drawings.

#### D.9.3 FABRICATION

As noted previously, pipe details are prepared by the fabricating activity. The preparation of pipe details is carefully integrated with NASSCO'S excellent production control system. The pipe detail group of the pipe shop determines from the finished arrangement drawings where breaks are to be made to define the separate pipe details. Piece numbers are then assigned to the details. All of this data is marked on a print of the arrangement drawing, which is sent back to the design activity. This data is then added to the original of the arrangement drawing.

The production control activity at NASSCO maintains tight control over the fabrication sequencing required to produce finished pipe details. This is accomplished by determining all steps that will be required to produce each pipe detail. A set of computer instruction cards are produced which are used to print out specific instructions to all activities involved in fabrication process, including those activities which must provide all required material. Instructions are issued at a time and in a sequence that will effect an efficient fabrication of pipe details. Pipe details are combined into work packages by the production control group. Work packages are assigned numbers and instructions are issued to the pipe shop on their assembly just as for the individual pipe details.

The pipe shop at NASSCO is well laid out and operations appear to be efficient. It was stated that the pipe shop is adopting a system of pre-cutting pipes to length in the storage area. A Vernon Pantograph is used for cutting saddles and branches. An Arrowsmith pipe expander is used for flaring the ends of copper-nickel and steel pipe. The pipe shop is equipped with excellent custom-built work benches which facilitate fabrication. Also, NASSCO makes its own gaskets on a Hytronic 50 Series USM press. Other equipment includes the usual saws and bending machines with a capacity of 1/2 inch to 12-inches (I.P.S.) in diameter. Steel pipe is bent to a radius of 5 ; copper and copper-nickel pipe is bent to a radius of 3D.

#### D.9.4 . INSTALLATION

A ship tour was not conducted. However, discussion with installation personnel indicated that installation of piping is done in a basically conventional manner.

#### D.9.5 ACKNOWLEDGEMENTS

For their excellent cooperation and participation in the Task S-4 project, we wish to thank the following people:

K. Evans - Director of Engineering  
G. Uberti - Chief Development Engineer  
J. Wasserboehr - Computer Support  
L. Russon - Assistant Marine Engineer  
J. Smith - Production Manager  
W. Freeze - Manager, Production Control  
R. Gonsolves - Layout  
W. Hickman  
J . B r o d i e  
W. Baker - Assistant Piping Superintendent  
W. Harrell - General Forman, Piping  
R. Ritchie. - Welding Supervisor

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SECTION D . 10  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
TODD SHIPYARDS CORPORATION  
LOS ANGELES DIVISION  
SAN PEDRO YARD

D.10.1 INTRODUCTION

A tour of the San Pedro Yard of Todd Shipyards Corporation, located in San Pedro, California, was conducted on February 3, 1976 for the purpose of collecting pipe technology data. Additional data was collected via telephone interviews. " . '

In general, Todd-San Pedro is a small, but capable yard presently involved in the construction of small tankers. Todd-San Pedro is also a major West Coast repair yard. They are making significant progress in upgrading facilities and production techniques in order to become more competitive over a wider range of ship types and sizes.

As of April 1, 1976, the following ships were under contract at Todd-San Pedro:

Quantity	Type	Propulsion	Size
4	Tanker	Diesel	35,000 dwt

A brief description of the piping design, fabrication, and installation activities at Todd-San Pedro is given in the following paragraphs. This description has been updated as necessary to April 1, 1976.

D.10.2 DESIGN

Todd-San Pedro's design and engineering staff handles a variety of work, including ship repair/conversion, some revision work on drawings supplied by the design agents, and pipe details. Some difficulty in maintaining an efficient design agent/shipbuilder relationship was noted. This difficulty is due primarily to the limited communication between the two activities - a problem shared by many shipbuilders not in close proximity with the design agent. Since little new design work is done, design methods are kept simple and conventional.

#### D.10.3 FABRICATION

Pipe shop work is organized into individual job packages, which includes all required material and labor. Pipe is cut and fabricated by the shop mechanics in accordance with pipe details prepared by design. Cargo pipe is cut and beveled at a facility outside of the pipe shop. Pipe benders are capable of handling pipe up to 8 inches (I.P.S.) and over. Swaged joints in heater coils were made by using hand tools with special mandrels. Some problems with the quality of brazed joints were noted, but the shop is planning to set up a training program to alleviate these. The shop also fabricates PVC piping; -heating is done with hand-held torches. Workmanship on this piping was very good.

The pipe shop buys gaskets, except those used for ship repair. Hangers are also bought, but they do have the capability of producing hangers in their blacksmith shop. It was also noted that manifolds were fabricated and tested in the shop, but gageboards were fabricated and tested on the ship.

#### D.10.4 INSTALLATION

A tour of a 35,000 dwt diesel-driven tanker was conducted. A large amount of service piping for the diesel engines was noted, which required fairly close interference control in some areas. Piping was generally arranged well and workmanship appeared to be good. No special techniques were observed.

#### D.10.5 ACKNOWLEDGEMENTS

We wish to thank the following people who made our tour of Todd-San Pedro both enjoyable and productive:

W: Burns - Assistant General Manager for Operations  
A. Monfalcone - Chief Planner  
W. Beyer - Pipe Shop Foreman  
J. Druskovich - Assistant Pipe Shop Foreman

SECTION D.11  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
FMC CORPORATION

D.11.1 INTRODUCTION

A tour of the Marine and Rail Equipment Division of FMC Corporation, located in Portland, Oregon, was conducted on January 30, 1976 for the purpose of collecting pipe technology data. Additional data was collected via telephone interviews.

FMC is a leading builder of barges and has recently entered the small tanker market. FMC has experienced some unique problems with their sudden entry into the shipbuilding industry under rather adverse conditions, but seems to be doing a remarkably good job in overcoming these problems. They are presently the only U. S. builder of gas turbine/electric commercial vessels.

As of April 1, 1976, the following ships were under contract at FMC:

Quantity	Type	Propulsion	Size
5	Tanker	Gas Turbine/Electric	42,000 dwt
4	Barge	-	-

A brief description of the piping design, fabrication, and installation activities at FMC is given in the following paragraphs. This description has been updated as necessary to April 1, 1976.

D.11.2 DESIGN

FMC has had to rely on a limited design staff for their first ship contract. Since the bulk of design work has been subcontracted out, very little information could be obtained in this area. It was noted, however, that their present design practices require a pre-fit of finished pipe assemblies before final installation. It is probable that this requirement will diminish as a more extensive design staff is developed.

### D.11.3 FABRICATION

Because of the limited shop facilities, FMC is relying heavily upon the use of elbows and mitered joints in lieu of pipe bends. Pipe is cut and end-prepared in the shop, but most fabrication must be done on ship to ensure proper fit-up. The epoxy-lined steel pipe used on the tankers is bought pre-lined and is also cut to length in the shop.

The most severe problem associated with fabrication seems to be the extremely poor quality of purchased valves and fittings, which often have to be reworked before final installations. Another problem noted is the lack of skilled shop workers.

### D.11.4 INSTALLATION

A tour of one of FMC's 42,000 dwt tankers was conducted. Despite the many problems noted, final shipboard installation of piping appeared to be of reasonably good quality. Piping arrangements were exceptionally good. Most piping is hung on standard Nelson or Grinnell hangers. One item of particular interest is the use of fiberglass pipe for the ballast systems. This pipe is fabricated with threaded fittings and appears to hold up quite well under normal shipboard conditions. Although a hard blow with a sharp object can damage the pipe, it is fairly impervious to welding and brazing sparks. Another item of special interest is the use of pre-fabricated toilet modules in the crews' quarters. These modules are easy to install and appear to be of exceptionally good quality.

### D.11.5 ACKNOWLEDGEMENTS

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For their excellent cooperation and efforts to make our survey of FMC a significant contribution to the Task S-4 project, we wish to thank the following people:

C. Boykin - General Manager  
E. Dunston - Piping Superintendent  
R. Miner - Test Engineer  
J. Lannon



SECTION D. 12  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC )  
LOCKHEED SHIPBUILDING-AND CONSTRUCTION COMPANY

D.12.1 INTRODUCTION

A survey of Lockheed Shipbuilding and Construction Company, located in Seattle, Washington, was conducted on January 29, 1976 for the purpose of collecting pipe technology data. Additional data was collected via telephone interviews.

Lockheed is presently involved in the construction of Navy sub-tenders and icebreakers. and in repair of all types of vessels. Although their piping design activities are limited, they appear to be efficient and quite flexible to suit the variety of work they handle.

As of April 1, 1976, the following ships were under contract at Lockheed:

Quantity	Type	Propulsion	Size
2	Sub Tender	(AS 39 - 40)	
1	Coast Guard Icebreaker		

A brief description of the piping design, fabrication, and installation activities at Lockheed is given in the following paragraphs. This description has been updated as necessary to April 1, 1976.

D.12.2 DESIGN

Diagrams are prepared in the usual manner and for the usual purposes of system portrayal, material ordering, and regulatory body approval. Except for stress calculations; all calculations are prepared manually: Related systems are grouped and are usually under the responsibility of one person.

Interference control for a specified area is accomplished by a rather unique device called an "aquarium". An aquarium is essentially a composite drawn on plexiglas sheets each of which represent a horizontal section through the composite region of the ship. Strata are spaced two feet apart, starting from the keel and going up to topside. The plastic sheets representing these strata are stacked in the same order in a frame, which is then placed near the designers involved with that region of the ship. If Interference free paths can be determined easily by sighting through the

various layers of the visual model. This system of interference control seems to work especially well for the modular construction that Lockheed is using, since aquariums can easily be built to suit the modular structural subassemblies.

Pipe details are prepared by the production planners in the shop. Pipes are detailed down to a size of 1-1/2 inches in diameter (I.P.S.) and are bent to a radius of 5D.

Design problems noted were the lack of skilled designers and engineers, the overcritical nature of the U.S. Coast Guard, and problems with the local unions. Also noted were the long lead time required for pumps and the lack of dimensional consistency of piping components from various vendors.

#### D.12.3 FABRICATION

In general, the pipe shop is comparable to most pipe shops surveyed, with no special techniques utilized. Pipe is stored outside and ordered by the pipe shop as needed. The storage of components prior to fabrication is neat and orderly, and there seems to be a good system for providing all of the material required for fabrication in a timely and economical manner.

The shop is arranged well with processing essentially straight-line. Pipe is cut to length in accordance with job orders using either torches or cutoff saws, depending upon the material. End-preparation is done with torches and grinders.

Pipe bending is done in a conventional manner to a radius of 3D or 5D. Non-ferrous pipe and fittings are fabricated via conventional brazing techniques. Ferrous pipe is first tack-welded in the shop and then finish-welded on the ship after fit-up. After pipe shop fabrication is complete, fabricated pipe is assembled into groups to be sent to storage or the ship.

#### D.12.4 INSTALLATION

Since no commercial ships are under construction at Lockheed, a ship tour was not conducted. However, discussions with installation personnel indicated that conventional techniques are utilized to hang, join, and test pipe on their Navy ships.

#### D.12.5 ACKNOWLEDGEMENTS

For their kind assistance in providing us with an interesting and informative tour of Lockheed, we wish to thank the following people:

R. B. Sorensen - Vice President - Works Manager  
W. E. Finne - Section Head - Mechanical -  
W. Aumick - Senior Manufacturing Planner  
A. Lyski - Sheet Metal Foreman  
E. Blaskovich - Pipe Shop Supervisor

SECTION D.13  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
TODD SHIPYARDS CORPORATION  
SEATTLE DIVISION

D.13.1 INTRODUCTION

A tour of the Seattle Division of Todd Shipyards Corporation, in Seattle, Washington, was conducted on January 28, 1976 for the purpose of collecting pipe technology data. Additional data was collected via telephone interviews.

Todd-Seattle is a small yard which builds a variety of Navy and commercial vessels up to 450 feet in length. They are also a major West Coast ship repair facility. Approximately 80 percent of Todd-Seattle's work is commercial ship repair and conversion.

As of April 1, 1976, the following ships were under contract at Todd-Seattle:

Quantity	Type	Propulsion	Size
1	Navy Hydrofoil (Conversion)	-	-
1	Phosphate Carrier	-	-
(not given)	Barge	-	-

A brief description of the piping design, fabrication, and installation activities at Todd-Seattle is given in the following paragraphs. This description has been updated as necessary to April 1, 1976.

D.13.2 DESIGN

Todd-Seattle's design activities often involve the use of Navy design agents. However, their design/engineering staff also appears to be quite capable of handling all aspects of original design. Piping design activities follow the traditional pattern of most other yards surveyed.

Diagrams are used for the usual functions of portraying overall system characteristics, making material estimates, and obtaining regulatory body approvals. Manually-prepared three-view orthographic arrangement drawings are used. Interference control is primarily through close designer liaison. All calculations are prepared manually. No special drafting

techniques are utilized. Pipe details are prepared by the shop.

One problem noted was the need for standards for valve operating gears, valve handwheel stems, and valve turn requirements. Long lead time requirement of marine piping components was also noted. Also, Todd-Seattle would like to see regulatory body approval on the use of commercial valves for marine applications.

#### D.13.3 FABRICATION

All pipe details are sketched and planned by a shop planner, who receives work orders from production control and schedules work accordingly for the shop. Pipe details are prepared on standard forms and grouped in booklet form by system. Fabrication status is also maintained on the forms. A two-inch template end is allowed at all structural breaks and at tight joints; most P-1 piping is templated. Piece numbers are assigned to all pipe details, and metal identification tags, prepared by the electrical department, are sent to the shop in the job order packages. Material men obtain pipe and all components prior to releasing a job order for fabrication. Generally, shop work is planned to be completed 8-10 weeks before needed by the ship.

Pipe, 6-inches (I.P.S.) in diameter or less is bent to a radius of 5D or 6D on Wallace benders. Some hot bending is done on pipes over 6-inches (I.P.S.) in diameter. End preparation is done with grinders.

Some small subassemblies, such as gageboards, reducing manifolds, and air stations are made up in the pipe shop. A pipe shop annex, which contains a small clean room, is used for stainless steel pipe.

Gaskets are normally bought. Hangers are made, although some consideration is being given to buying hangers on future contracts.

Steam is used for pipe cleaning before and after fabrication. After fabrication all piping is palletized for delivery to the ship.

#### D.13.4 INSTALLATION

A tour of the Navy hydrofoil vessel was conducted. An impressive orbital welder, made by Dimetrics and loaned by

the Navy, was being utilized to weld heavy-walled hydraulic piping. It was noted that resulting joints do not have to be X-rayed, since all required weld quality data is recorded on a strip chart on the unit's main console as the joint is welded. Although the welding was being done in the machinery space, the console was located on the main deck.

Another item of particular interest was we use of fiberglass pipe in lieu of galvanized pipe. A run of 4-inch diameter fiberglass circulating water piping was noted to be of exceptional quality and durability. Pipe is end-prepared and glued easily on the ship, with no apparent problems. Appearance is good so that no painting is required. Todd-Seattle also uses Devron Multi-Tube extensively for gage lines, control air-systems, and tank level indicating systems.

#### D.13.5. A C K N O W L E D G E M E N T S

For their-contribution--to the Task S-4 effort we wish to thank the following people: ---

- H. Schaefer - Production Manager
- R. Heseltine - Machinery Group Supervisor - Engineering
- E. Lynch - Assistant Production Manager
- E. Larson - Foreman - Pipe Shop
- D. Craig - Assistant Foreman - Pipe Shop .
- J. Methven - Pipe Detailer

SECTION D.14  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
GIBBS AND COX, INC.

D.14.1 INTRODUCTION

A brief interview with representatives of Gibbs and Cox, Inc., located in New York, N.Y., was held on February 17, 1976 for the purpose of collecting data relative to design agent functions and design practices. The following paragraphs provide a summary of findings.

D.14.2 DESIGN AGENT FUNCTIONS

Gibbs and Cox, Inc. performs both basic design work for prospective owners and detail design work for the shipbuilders. As a representative for the owner, they work closely with the owner to ensure that the basic design of a ship meets all of the owner's requirements. They also work closely with the shipbuilder to ensure that detail drawings are compatible with the shipbuilder's capabilities.

D.14.3 DESIGN PRACTICES

For the purpose of performing design work, the design staff at Gibbs and Cox, Inc. is divided into hull, machinery, and electrical - weapons groups. Structural background drawings, pre-printed on vellum via a photographic process, are used by each of these groups to prepare their arrangement drawings. For piping design, color-coded design control maps are used for interference control. This is essentially a composite worksheet upon which systems are portrayed by colored linework. To warn the prospective shipbuilder of any especially congested areas, so-called "zero-clearance areas" are clearly marked on the arrangement drawings. Notes and other written matter are typed on transfers using an IBM typewriter.

D.14.4 ACKNOWLEDGEMENTS

We wish to thank the following people who took time out from busy schedules to provide us with information on Gibbs and Cox, Inc.

J. P. Doyle - Vice President and Chief Engineer  
W. Kataryniak - Department Head, Design Department -  
Machinery Division

SECTION D.15  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
J. J. McMULLEN, INC.

D.15.1 INTRODUCTION

A brief interview with representatives of J. J. McMullen, Inc. , located in New York, N.Y., was held on February 18, 1976 for the purpose of collecting data relative to design agent functions and design practices. The following paragraphs provide a summary of findings.

-- D.15.2 D E S I G N      A G E N T      F U N C T I O N S --

J. J. McMullen, Inc. acts primarily as a representative for the owner, and therefore does not usually become greatly involved in detail design work. They work closely with the owner and regulatory bodies to ensure that the basic design of a ship meets all requirements. We asked them to comment on any problems that owners have noted relative to the quality of work performed by the shipbuilders. In response to this question they stated that owners are generally not satisfied with the quality of instruction manuals provided with the ship by the shipbuilder. Another problem noted was the shipbuilder's incorporation of detail design features which are not compatible with the owner's requirements.

D.15.3 DESIGN PRACTICES

Design work involves the preparation of system diagrams and material specifications, both in a basically conventional manner. One problem related to piping design that was noted is the fact that regulatory body requirements often provide too many choices in the selection of materials for a particular system. The limitation of one material for a given system might lead to more standardization throughout the shipbuilding industry and improve material availability. The use of Schedule 40 carbon steel pipe could be replaced by the use of Schedule 80 black iron pipe for many services. Fiberglass pipe could be used for cooling water, main circulating water, potable water and all non-vital services.



#### D.15.4 ACKNOWLEDGEMENTS

For their kind assistance in providing us with information on the activities of J. J. McMullen, Inc., we wish to thank the following people:

G. Knight - Vice President  
J. C. Halfmann - Technical Assistant, Engineering  
Division  
E. Kierenia - Department Head, Engineering Support  
E. E. Lithen - Systems Engineer

SECTION D.16  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
M. ROSENBLATT AND SON, INC.

D.16.1 INTRODUCTION

A brief interview with representatives of M. Rosenblatt and Son, Inc., located in New York, N.Y., was held on February 18, 1976 for the purpose of collecting data relative to design agent functions and design practices. The following paragraphs provide a summary of findings.

D.16.2 DESIGN AGENT FUNCTIONS

M. Rosenblatt and Son, Inc. serves both as a basic design agent for ship owners, and as a detail design agent for shipbuilders. In some cases, detailed piping design includes pipe details.

D.16.3 DESIGN PRACTICES

Diagrams are prepared in a conventional manner for the usual purposes of system portrayal and regulatory body approval. Interference control is primarily by designer liaison; no composites are used. Arrangement drawings are prepared on reproducibles of the ship structural drawings.

They feel that some pipe sizes in the range of 0-4 inches (I.P.S.) could be eliminated in the interests of standardization, but that elimination of some pipe sizes above 4 inches (I.P.S.) would not allow sufficient flexibility in designing piping systems.

Problem areas noted were the lack of uniform requirements among the regulatory bodies and the need for more standardization. The idea of a composite specifications document seemed to be appealing to this design agent; they suggested that the VSMF Microfilm Company might be able to prepare and maintain such a document at a reasonable cost.

D.16.4 ACKNOWLEDGEMENTS

For their cooperation in providing us with information on M. Rosenblatt and Son, Inc., we wish to thank the following people:

N. Maniar - Technical Vice President  
A. Isaacson - Head, Marine Engineering  
                    Basic Ship Design Group  
A. Mannino - Section Head, Machinery and Piping

SECTION D.17  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
GEORGE G. SHARP, INC.

D.17.1 INTRODUCTION

A brief interview with representatives of George G. Sharp, Inc., located in New York, N.Y., was held on February 17, 1976 for the purpose of collecting data relative to design agent functions and design practices. The following paragraphs provide a summary of findings.

D.17.2 DESIGN AGENT FUNCTIONS

George G. Sharp, Inc. serves only as a basic design agent for ship owners, and therefore does not usually become involved in the detailed design of a ship. During the interview they mentioned several problem areas that owners have noted. One problem is the poor quality of ship instruction books received from the shipbuilder. Another problem is the incompatibility of some shipyard methods with owner requirements. For example, one owner preferred that the shipbuilder use screwed fittings in lieu of welded fittings because the ship was to be used on trade routes where qualified welders were scarce and therefore maintenance on welded systems would be a problem. Also noted was the owner's reluctance to use novel methods over well-proven methods, since a failure due to an unproven method could result in a disastrous loss of revenue from the ship.

D.17.3 DESIGN PRACTICES

George G. Sharp, Inc. generally provides only the ship detail specifications and the system diagrams to the shipbuilder. No special techniques are utilized to prepare the system diagrams.

This design agent felt that some form of composite specifications document was desirable. They also felt that the use of galvanized pipe should be eliminated, and that the use of plastic and fiberglass pipe should be increased.

#### D.17.4 ACKNOWLEDGEMENTS

We wish to thank the following people for their time and efforts in providing us with information on George G. Sharp, Inc.

R. G. Giblon - President  
A. Chin - Chief Marine Engineer  
C. F. Gradilone - Assistant Chief Marine Engineer  
G. E. Emberton - Marine Engineer  
W. A. Musciano - Chief Mechanical Draftsman  
H. A. Hilliker

SECTION D.18  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
CRIPPEN PIPE FABRICATION CORPORATION

D.18.1 INTRODUCTION

A tour of Crippen Pipe Fabrication Corporation, located in Brooklyn, New York (Brooklyn Navy Yard), was conducted on February 19, 1976 for the purpose of collecting data on the Crippen methods of pipe fabrication.

Although the plant was shut down for the day, we were given a slide presentation which described the evolution and present status of the company. We were also given a commercial brochure which describes the overall Crippen process. For completeness, this brochure is included herein and related comments are noted in the following paragraphs.

D.18.2 FACILITIES, EQUIPMENT, AND PERSONNEL

In general, facilities at Crippen are geared for high-volume hot pipe bending and fabrication. We found that the facilities described in the brochure were well-equipped and arrangements were designed for maximum efficiency. Mr. Crippen stated that he is fortunate in having skilled and qualified personnel to perform bending and other fabrication processes.

D.18.3 HOT-BENDING PROCESS

Crippen's hot-bending capabilities are described in the brochure. Mr. Crippen stated that he has not issued any licenses for use of this process by other companies, but that he would pursue the subject with anyone who was interested.

Relative to the process described in the brochure, it should be noted that thin-walled pipe is packed with sand prior to bending. Also, hot bending is done entirely within a specified temperature range for the material involved and with a special bending jig so as to assure retention of roundness, the mechanical/chemical properties of the material, and an absence of wrinkles, buckles, and other defects in the finished product.

. —

As noted in the brochure, Crippen is also capable of performing other phases of pipe fabrication, such as welding or brazing of fittings, cleaning, and testing. Fabrication is accomplished in accordance with the customer's drawings and related documents.

#### D.18.4 ACKNOWLEDGEMENTS

We wish to thank Mr. H. Crippen for his time and effort spent in providing us with..a tour of his facilities.



## CRIPPEN PIPE FABRICATION CORPORATION

Crippen Pipe Fabrication Corporation is a newly established minority company primarily concerned with the bending and welding of fabricated pipe assemblies to the most exacting specifications.

The Crippen Patented Hot Pipe Bending Apparatus quickly produces pipe bends that meet the increasingly critical criteria for bends, minimizing thinning, flattening, and wrinkling.

Welding and other operations are carried out by experienced craftsmen trained to the most exacting requirements.

We are interested in pipe fabrication  $2\frac{1}{2}$  pipe size and larger in carbon, alloy, and stainless steel. We have virtually no limitation in size or weight for fabrication since our building is equipped with 20 ton bridge cranes which have forty-two (42) feet under the hook. We are presently limited to 36" O.D. pipe bends due the sizes of our furnaces for heating the pipe prior to bending. We are not limited in the wall thickness we can handle for either fabrication or bending.

We hold ASME Certificates of Authorization to perform all types fabrication required for Power Boilers, Unfired Pressure Vessels, and Pressure Piping. All our welders are qualified in accordance with the requirement of the ASME Boiler and Pressure Codes and we have qualified

- over -

procedures for heavy-wall welding (up to 6" thickness) of Carbon Steel, Chrome Moly Steel, Stainless Steel, Incoloy, Aluminum and Copper-Nickel Alloys. We have completed projects requiring U.S. Navy and U.S. Coast Guard specification and inspection.

The following companies are some of those to whom we have supplied fabricated piping assemblies of various complexities, materials and codes:

ALLEGHENY POWER SERVICE  
ALLIS CHALMERS  
AMOCO  
BURMAH OIL  
CONSOLIDATED EDISON  
DUPONT  
GETTY OIL  
LONG ISLAND LIGHTING  
MOBIL OIL  
NEWPORT NEWS SHIPBUILDING  
PETRO-CHEM DEVELOPMENT  
RILEY STOKER  
SEATRAN SHIPBUILDING  
UNION CAMP  
EXXON, U.S.A.  
GENERAL ELECTRIC COMPANY  
COMBUSTION ENGINEERS, INC.  
INDUSTRIAL PROCESS ENGINEERING, INC.

Materials for which we have qualified welding procedures and welders in accordance with ASME Section IX are:

CARBON STEEL  
CHROME MOLY STEEL  
STAINLESS STEEL  
INCOLLOY  
ALUMINUM  
COPPER NICKEL

We have fabricated to the following codes and standards:

U.S. COAST GUARD  
U.S. NAVY (Mil Standards)  
A.P.I.  
A.S.M.E.  
Various A.N.S.I.



- 3 -

Our authorized inspection agency is Hartford Steam Boiler Insurance and Inspection Company.

We have both local and national collective bargaining agreement with the United Association of Steamfitters and Plumbers and can affix the union label whenever required.

May we further mention. that we are able to ship completed. piping assemblies anywhere in we world as we have both rail sidings leading into our plant and a deep water berth at the rear of our plant. We have recently completed and shipped Chrome-Moly Steel Piping Assemblies to Pertamina in Indonesia; Pre-purifier Skid Assemblies to Norway and Turkey; and offshore piping assemblies to the-Bahamas.

We are in a position to accept orders immediately and would welcome the opportunity to service your company.

This is an invitation to visit, a welcome, and a guide to the Crippen Plant, which is located in the former Brooklyn Navy Yard, as well as a list of facilities available.

  
Henry O. Crippen  
p r e s i d e n t

## LIST OF FACILITIES

### MANUFACTURING PLANT

Production Building.....	25,000 Square Feet
Inspection and Storage Building.....	30,000 Square Feet
Furnace Building.....	1,500 Square Feet
Service Building.....	10,000 Square Feet
Outside Storage.....	Space Available As Required

### INSPECTION BUILDING ( No. 268 )

One Main Inspection and Storage Building served by  
Various Jib Cranes with Electrical Hoists

- 1 - K & E Transit
- 1 - Radiograph Cell
- 1 - Dark Room with Complete Facilities
- 1 - Ultrasonic Tester - Krautkraemer Model D
- Magnaflux Inspection Equipment Model P90
- Dye Penetrant Inspection Equipment
- Hydrostatic Testing Equipment
- Vacuum Testing Equipment
- 1 - Railroad Siding into Inspection Building

### PRODUCTION BUILDING ( No. 269 )

One Main Production Building served by

- 2 - 20 Ton Capacity Bridge Cranes
- 2 - 5 Ton Capacity - 35' Reach Jib Cranes with Electrical Hoists
- Various 2 and 3 Ton Capacity Jib Cranes with Electrical Hoists
- 1 - 3½ Ton Capacity Fork Lift
- 1 - 4½ Ton Capacity Fork Lift
- 1 - 10 Ton Capacity Mobil Hydraulic Crane
- 1 - Railroad Siding into Production Building

### FURNACE BUILDING ( No. 71 )

One Car Type Furnace served by

- 1 - 5 Ton Capacity - 22' Reach Jib Crane with Electrical Hoists
- 1 - Quench Tank
- 1 - Mobil Weather Protection Shed
- 1 - Railroad Siding to Furnace Building

## EQUIPMENT

### CUTTING AREA

- 1 - Pipe Cutting Table - Gas Torch
- 1 - Portable Pipe Cutoff Machine - Gas Torch
- 1 - Neck and Miter Cut Attachment
- 1 - Wallace 3400 Abrasive Cut Machine
- 1 - Armstrong-Blum Model 8/M2 Marvel Band Saw
- Electric Arc Cutting Equipment

### BENDING AREA

- 1 - Sand Tower with Vibrators
- 1 - Gas Fired Bending Furnace with Fully Automated Controls  
12'-9" Long, 4'-0" Wide, 4'-0" High \*
- 1 - Patented Hot Pipe Bending Apparatus
- 1 - Wallace Model 500-6 5/8 Cold Bender

### FITTING AND WELDING AREA

- 9 - Leveling and Layout Tables
- 19 - Welding Machines:  
Automatic and Semi-Automatic Submerged Arc,  
MIG, TIG, Flux Cored, and Manual Metal Arc Equipment
- 2 - Aronson Model HD 60 Positioners
- 2 - Ransome Model 40 Positioners
- 1 - Pandjiris Model 15.4 Positioner
- 1 - Ransome Turning Rolls Set Model SA 15 PR

### MACHINING AREA

- 1 - Vertical Drill Press
- 3 - Lathes - 1 Hollow Spindle Turret, 1 Turret, 1 Standard
- 4 - Pedestal Grinders
- 2 - Rotating Head Beveling Machines (Portable)
- 1 - Pipe Bevel Grinder
- 1 - B & D Model 741 Magnetic Drill Press

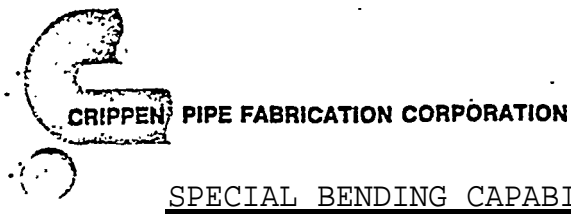
### HEAT TREATING AREA

- 1 - Gas Fired Furnace - Car Type with Fully Automated Controls  
28'-0" Long, 12'-0" Wide, 12'-0" High \*
- 1 - Gas Fired Heat Treatment Furnace with Fully Automated Controls  
10'-0" Long, 3'-0" Wide, 3'-0" High \*
- 1 - 160 KVA Electric Arc Model CGSF-10  
Induction Stress Relieving Unit with Fully Automated Controls

### FINISHING AREA

- 1 - Sanstorm Model FPR Grit Blasting Unit
- 1 - Distilled Water Tank & Demineralizer
- Painting Equipment

\* Inside Heating Chamber Dimensions



### SPECIAL BENDING CAPABILITIES

It is expected that many piping configurations which are not practical or economical with current hot bending methods can be produced economically with the Crippen hot bending apparatus. Crippen Pipe Fabrication Corporation sales engineers will work with the client's engineers and designers to insure that maximum advantage is taken of these economic features.

CREDIT, the name of the patented hot bending apparatus invented by Mr. Crippen, produces wrinkle-free, full-area bends at a high production rate maintaining close tolerances. In addition to this capability, CREDIT enables the hot bender to bend-form 4, 5 and 6-bend compound pieces without a butt weld. A compound piece is defined as an assembly containing bends in more than one-plane. Current industry bending equipment and methods usually require that these compound pieces be assembled from a series of single bends welded together. .-

Additional features of CREDIT which can provide the basis of customer design economies are:

a) CREDIT permits pipe to be bent in a continuous arc of up to 360 degrees without a weld.

b) CREDIT permits the most complicated compound bends to be bend-formed with zero tangents (no straight section) between bends.

c) CREDIT offers safety for alloy pipe bending because of the rapid procedure which enables the bending to be finished while the heated pipe is at the proper hot bending temperature. For example, it will permit a 90-degree bend to be formed in a 12" diameter pipe in less than 3 minutes.

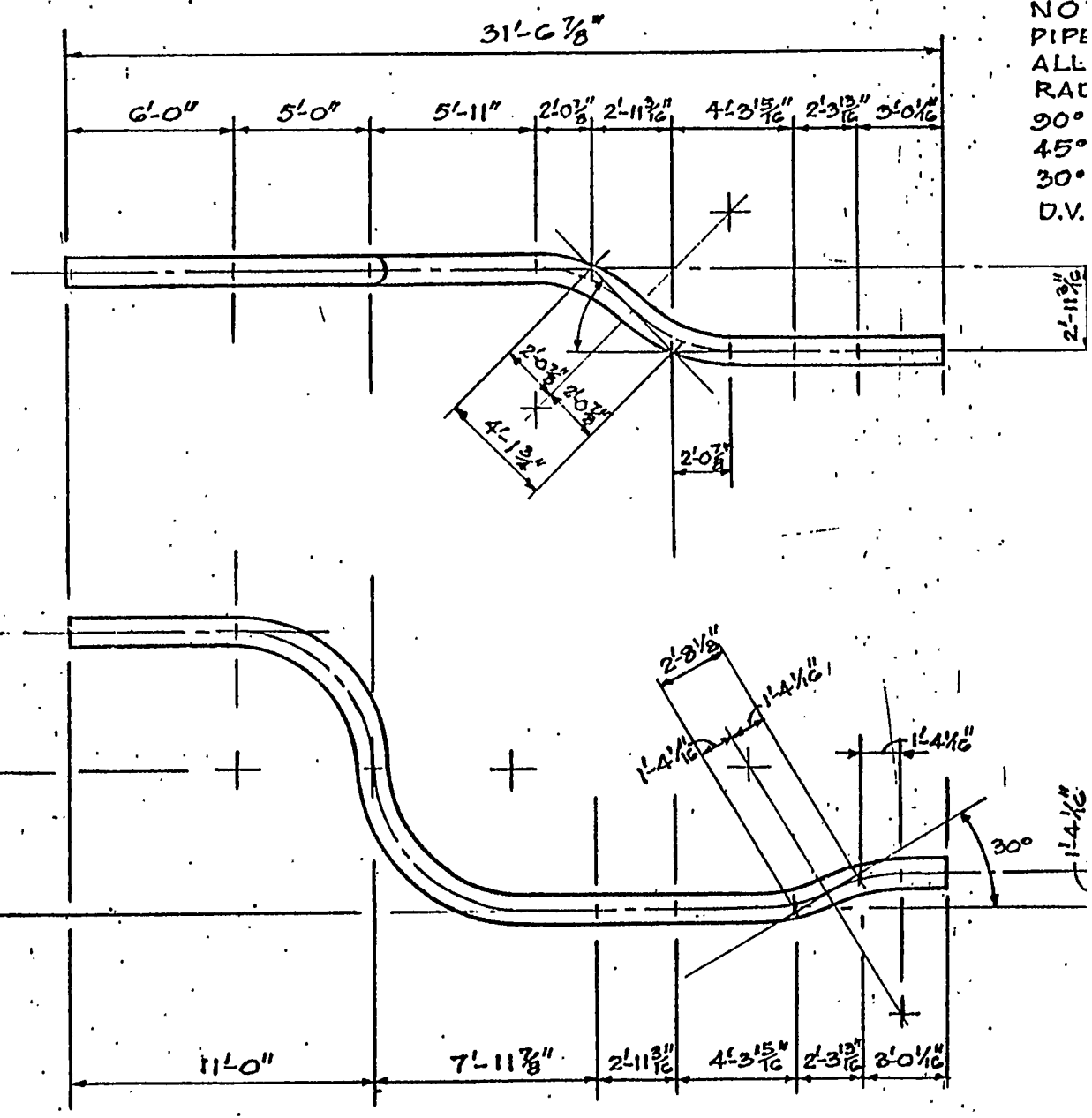
d) The precision accuracy of CREDIT will enable pipe to be bent after other fittings or attachments have been welded to the sections outside of the bend area.

e) CREDIT will enable compounds to be bend-formed as many as three (3) different radii.

The examples cited are only a few of the features of CREDIT. . . CREDIT provides more than a dozen features that are not practical with conventional hot pipe bending equipment.

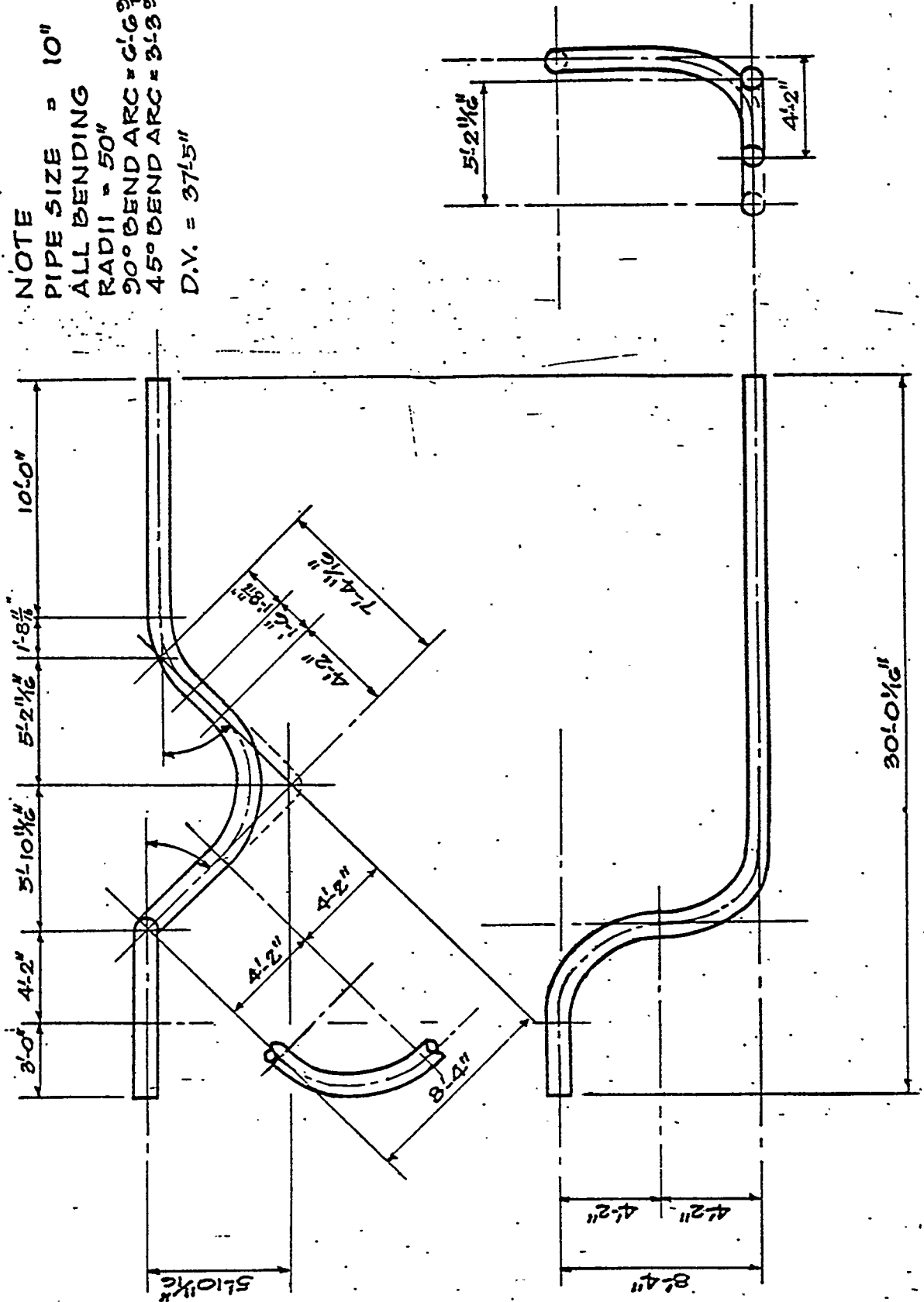
The drawings included in this brochure show 4, 5 and 6-bend compound pieces which can be formed without intermediate butt welds using CREDIT. These pieces require multiple-rotation, Zero tangent and both clockwise and counter-clockwise bending.

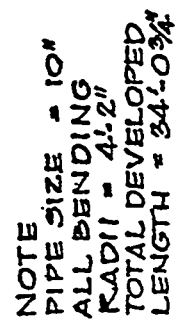
NO  
PIPE  
ALL  
RAC  
90°  
45°  
30°  
D.V.



D-57

NOTE  
PIPE SIZE = 10"  
ALL BENDING  
RADII = 50"  
90° BEND ARC = 6'-6 3/4"  
45° BEND ARC = 3'-3 9/16"  
D.V. = 37'-5"





SECTION D.19  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
COSMODYNE CORPORATION

D.19.1 INTRODUCTION

A tour of Cosmodyne Corporation, located in Torrence, California, was conducted on February 2, 1976 for the purpose of collecting data on cryogenic pipe fabrication. A summary of findings is provided in the following paragraphs.

D.19.2 FACILITIES, EQUIPMENT, AND PERSONNEL

Cosmodyne specializes in the fabrication of cryogenic piping. Facilities, equipment, and personnel are all geared to this specialty. At the time of the tour they were fabricating and testing Schedule 10 stainless steel piping assemblies for use on the LNG vessels under construction at Newport News Shipbuilding.

Facilities include several large production buildings, and outdoor fabrication and storage areas. The main office, located next to the production areas, houses the administrative, design, and engineering staffs.

Equipment includes the usual array of standard pipe fabrication machinery and a number of specialized items. For end-preparation and saddle cuts, a Thermal Arc Pac 22E plasma-arc unit is used. A rotary jig, to which a hand-grinder is attached, is used for grinding bevels. Manual TIG welding is used.

Among the specialized items observed is a custom-made hydraulically-operated, spring-loaded pipe expander, which is used both to align joints and to correct mating pipe sections for excessive ovality. A self-propelled pipe expander, developed primarily for the petro-chemical industry, is also used to align and expand pipe. This device is especially useful when the joint to be welded is inaccessible from the inside. The device rents for \$1500 per month; this fee includes a spare unit which is always provided by the vendor.

Also noted was the use of a bellows device with a plastic insert which is used as a purge dam, and the use of custom made jigs to support large-diameter pipe.



### **D.19.3 . ACKNOWLEDGEMENTS**

For their kind assistance in providing us with a tour of Cosmodyne Corporation, we wish to thank the following people:

N. Tonjes - Contract Administrator  
R. Denzel - Manager, Project Development  
F. J. Grillo - Shop Supervisor

SECTION D.20  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
TELEDYNE PINES

D.20.1 INTRODUCTION

A tour of Teledyne Pines, located in Aurora, Illinois, was conducted on January 26, 1976 for the purpose of collecting data on the state-of-the-art in pipe fabrication equipment. At the time of this writing, commercial brochures had not yet been received, so that no detailed information on their product line could be given. However, a brief summary of findings is provided in the following paragraphs.

D.20.2 PIPE FABRICATION EQUIPMENT

Teledyne Pines manufactures a variety of tube and pipe benders, extrusion benders, and specialized fabrication equipment. Our tour of facilities indicated that the Pines booster-bending machines at Newport News Shipbuilding still basically represent the state-of-the-art in domestic pipe bending technology. The only advancement in this area is the development of numerical-control equipment for the machines. Many of the machines produced by Pines can easily be connected to use the numerical-control equipment. It does not appear that completely automated pipe handling systems, similar to those produced by foreign manufacturers, are planned for future production by Pines.

D.20.3 ACKNOWLEDGEMENTS

We wish to thank the following people for providing us with an interesting and informative tour of Teledyne Pines:

R. C. Cain - Sales Engineer  
J. Dornblaser - Sales Representative

SECTION D. 20  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
TELEDYNE PINES

D.20.1 INTRODUCTION

A tour of Teledyne Pines, located in Aurora, Illinois, was conducted on January 26, 1976 for the purpose of collecting data on the state-of-the-art in pipe fabrication equipment. At the time of this writing, commercial brochures had not yet been received, so that no detailed information on their product line could be given. However, a brief summary of findings is provided in the following paragraphs.-

D.20.2 P I P E F A B R I C A T I O N E Q U I P M E N T

Teledyne Pines manufactures a variety of tube and pipe benders, extrusion benders, and specialized fabrication equipment. Our tour of facilities indicated that the Pines booster-bending machines at Newport News Shipbuilding still basically represent the state-of-the-art in domestic pipe bending technology. The only advancement in this area is the development of numerical-control equipment for the machines. Many of the machines produced by Pines can easily be connected to use the numerical-control equipment. It does not appear that completely automated pipe handling systems, similar to those produced by foreign manufacturers, are planned for future production by Pines.

D.20.3 ACKNOWLEDGEMENTS

We wish to thank the following people for providing us with an interesting and informative tour of Teledyne Pines:

R. C. Cain - Sales Engineer  
J. Dornblaser - Sales Representative

SECTION D.21  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
CONRAC CORPORATION  
MACHINE TOOL DIVISION

D.21.1 INTRODUCTION

A tour of the Machine Tool Division of Conrac Corporation, located in Westminster, California, was conducted on February 2, 1976 for the purpose of collecting data relative to the state-of-the-art in pipe fabrication equipment. A summary of findings is provided in the following paragraphs.

D.21.2 FABRICATION EQUIPMENT

The Machine Tool Division of Conrac Corporation builds tube and pipe end preparation and finishing equipment, tube and pipe benders, Van-Stone flanging machines, automatic welding machines for structural beam fabrication, and wire marking machines. During the tour a demonstration of 1-1/2 D bending on a Conrac booster-bender, a demonstration of their Van-Stone flanging machine, and a demonstration of an end-preparation machine were given; data collected during the tour included commercial brochure on all of their products.

The Conrac Model 4EP Pipe End Preparation Machine offers the advantages of quick set-up and changeover tooling, uncomplicated, easy to read controls, and consistently squared and deburred pipe ends. The machine has a capacity of 3/4 inches (I.P.S.) to 4 inches (I.P.S.) on Schedule 10, 40, and 80 pipe. It will handle the following materials: A53 and A106, Grade A and B, A587, USS420, Stainless Steel, 300 series. An outside bevel of 37-1/2 degrees is produced. The machine appeared to produce high quality bevels quickly and efficiently.

The demonstration of the Conrac 1-1/2D Hydraulic Bender was most impressive. A sample bend was made and cross-sectioned to show pipe intrados and extrados. No defects were noted in this sample and it was stated that a maximum of 18 percent wall thinning is guaranteed for these bending machines.

The 8-inch (1. P.S.) capacity Conrac Van-Stone Flanging Machine was demonstrated using a 4-inch (1. P.S.) pipe sample. The pipe was placed in the machine and centered. A rotating mandrel quickly upset the end of the pipe to form the Van-Stone flange lip. The pipe material in the immediate area of the cold forming operation showed no surface defects and the quality of the finished product was excellent.

#### D.21.3 ACKNOWLEDGEMENTS

We wish to thank the following people for providing us with an interesting and informative tour of the Machine  
- Tool Division of Conrac Corporation:-

G. B.Dunn - General Manager  
A. Kunish - Chief Engineer

SECTION D.22  
FACILITY SURVEY DOCUMENTATION  
(DOMESTIC)  
NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

D.22.1 INTRODUCTION

A visit to the Naval Ship Research and Development Center (NSRDC) at Carderock, Maryland was made on October 17, 1975 for the purpose of obtaining information relative to the Computer Aided Piping Design and Construction (CAPDAC) project, presently under development at NSRDC. A summary of the CAPDAC engineering analysis recently completed by NSRDC and a demonstration of computer-aided design capabilities was given.

D.22.2 THE CAPDAC PROGRAM

The CAPDAC research program has as its ultimate objective the development of a comprehensive computer-based piping design and construction system directly usable by shipyards for both Navy and commercial work. The CAPDAC program is an integral part of the Computer-Aided Ship Design and Construction System (CASDAC), which covers all aspects of ship design and construction. The total CASDAC program is being developed with input from both Navy and commercial oriented industry consultants. The development of the entire program is expected to take from eight to ten years.

The first phase of the CAPDAC program has just been completed and is fully described in a six-volume report which is being sent to representatives of all the major Navy and private shipyards, as well as to the various design agents. Essentially this report is an engineering analysis of the piping design and construction process in the basically non-computerized state-of-the-art environment. The analysis examines in detail every known aspect of present day marine piping production and identifies the various types of data involved and their sources. The report also includes the basic plan-of-action for the development of the remaining phases of the CAPDAC program.

The CAPDAC program will allow the user to design piping systems within a totally computer-based environment if desired or to select only a designated subsystem to handle a specific phase of the piping design process. The total CAPDAC data base will include a ship design file, an image file, a digital model, and a material control system and

master material files. The ship design file and the digital model include such items as pipe schedules, pump characteristics, and lists of material; the image file contains such items as the graphical portions of diagrammatic and arrangement drawings, system operational data in text format, and composites and overlay drawings as prepared manually; the material control system and master material files will contain up-to-date material estimates, provide means to perform material trade-offs, keep material inventories, provide information on make-or-buy decisions, develop material ordering schedules, and perform grouping functions. In addition to these capabilities CAPDAC will contain the usual computational software for performing pipe sizing, stress analysis, etc.

#### D.22:3 C O M P U T E R G R A P H I C S :

To facilitate the preparation of composites, arrangement drawings, and pipe details, NSRDC is developing the capability to arrange and digitize design configurations via computer graphics. Basically, the computer graphics hardware allows the designer to optimally arrange equipment and piping on a CRT terminal, to obtain hard-copy printouts of the design, and to digitize the design in a very simple manner so as to establish a data base from which other required documents can automatically be prepared by a central computer system. The system, when operational, will greatly reduce the time now required to manually produce drawings and will provide a simple means of setting up data bases for use by the total CAPDAC system.

#### D.22.4 ACKNOWLEDGEMENTS

We wish to thank Mr. Harry Sheridan, chairman of the CAPDAC Advisory Committee, and his associates at NSRDC for their valuable participation in the Task S-4 project effort.

APPENDIX E

PROPOSED  
FACILITY SURVEYS  
(FOREIGN)

BACKGROUND INFORMATION  
AND  
RATIONALE FOR MAKING ON-SITE SURVEYS



## INTRODUCTION

For the purpose of collecting detailed data related to the Task S-4 Advanced Pipe Technology project, four European shipyards have been selected for making on-site surveys. These yards are:

1. Astilleros y Talleres Del Noroeste, S.A. (ASTANO), located in El. Ferrol Del Cadilla, Spain
2. Italcantieri, S.P.A., located in Trieste, Italy
3. Howaldtswerk-Deutsche Werft AG, located in Kiel,  
W . G e r m a n y
4. Odense Steel Shipyard, Ltd., located, in ~indo

This selection was based on a careful study of available literature, trip reports, and of data collected during discussions with people familiar with many of the shipyards around the world. Based on actual time spent at shipyards during the Task S-4 domestic shipyard surveys, it was determined that 1-1/2 to 2 days should be spent at each yard selected. This time frame allows us to adequately cover two shipyards per week. Due to budgetary constraints, we limited the total number of yards to be surveyed to four.

The problems associated with selecting the four "best" yards for the purpose required us to establish a systematic process of elimination, which is outlined as follows:

1. Based on available information, fifteen yards were identified as having advanced pipe technology.
2. From this field of fifteen, the four Japanese yards were eliminated on the basis that the best of their technology had been acquired by two of the European yards in the yards originally identified. Of these two, Italcantieri-Monfalcone appears to possess the best overall piping technology in the entire Mediterranean Sea area; thus, this yard was selected for making an on-site survey on the basis that it represents a mix of some of the best European. and Japanese technology.
3. Out of the ten yards left to select from, two were eliminated on the basis that the rather small and highly specialized ships that they produce are not

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truly representative of the types that are currently produced in the U.S. and therefore the value of techniques used is somewhat questionable.

4. Three of the remaining eight were eliminated on the basis that production levels are apparently slacking off rapidly at present, due to lack of new contracts.
5. Of the five excellent yards remaining, two were in Spain, one was in Denmark, one in Sweden, and one in W. Germany. Based on the best available information, ASTANO (Spain), Odense (Denmark), and HDW-Kiel (W. Germany) were selected. The ASTANO Yard appears to be in the final stages of modernizing their pipe shop facilities and is certainly representative of the best Spanish technology. The Lindo Yard of Odense is one of the most efficient shipyards in the western world and is representative of the best Scandinavian technology. Avondale Shipyards, Inc. has done much research in the field of piping technology and based on their recommendation and information we selected HDW-Kiel, which from all indications, is one of the most efficient and versatile shipyards in the world and is certainly representative of the best German technology.

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- SECTION E.1

PROPOSED FACILITY SURVEY  
ASTILLEROS Y TALLERES DEL NOROESTE, S.A. (ASTANO)  
EL FERROL DEL CADILLA , SPAIN

1.1 BACKGROUND INFORMATION

The ASTANO Yard is a major factor in Spain's present status as the third largest producer of ships in the world. It is also the only known Spanish yard currently capable of constructing tankers up to 450,000 dwt. As of January 1976, the following ships were under contract to be built at ASTANO:.

<u>Quantity</u>	<u>-Type</u>	<u>-</u>	<u>Size</u>
1	Tanker (turbine )		274,045 dwt
2	"- Tanker (turbine)		274,075 dwt
3	Tanker (turbine)		300,000 dwt
1	Tanker (turbine)		361,470 dwt

From available literature it is known that ASTANO is one of the most modern yards in Europe. Information obtained from J. J. McMullen, Inc. indicates that the yard is in the final stages of updating pipe shop facilities, possibly with the aid of outside technical assistance. A representative of this design agent stated that ASTANO had one of the best pipe shop facilities that he had seen.

The key to ASTANO'S success is the phenomenal speed at which they are able to build large tankers. The entire yard is geared for flow-line series production. Since only one building dock is utilized, dock time must be held to an absolute minimum to meet schedules. Construction time prior to launch is said to be 3-4 months, and final outfitting time after launch is said to be 1-2 months. Such schedules impose severe problems relative to outfitting. It is not known how ASTANO solves these problems, but it is probable that they rely heavily upon computers for design work (as at most Spanish yards) and on numerical control equipment for fabrication. This, however, does not account for the rapidity at which piping installation must precede. It is known only that outfitting of piping systems is accomplished in modular sub-assemblies which are installed in hull block sections as construction of the ship proceeds in the building dock.

ASTANO also maintains a high-quality apprentice school and its graduates are reported to be among the best trained in Europe. Their role as skilled craftsmen in a largely mechanized yard is a unknown factor in ASTANO'S success.

## 1.2 RATIONALE FOR MAKING ON-SITE SURVEY

The primary objective in making an on-site survey of ASTANO is to study high-volume series production techniques as applied to ships requiring a large amount of piping (steam turbine tankers). It is anticipated that such a study could prove useful in determining the level of automation required at U. S. yards to produce ships of comparable complexity at the same or lower level of series production. Specific areas of study would be:

### DESIGN

1. the extent to which "standard" ship designs are modified to suit owner preferences;
2. the use of design and material standards;
3. the extent to which computers are utilized for detail design;
4. the types of documents prepared by the design activity;
5. methods of interference control used to ensure accurate fit-up of pre-outfitted block sections;

### FABRICATION

1. the production control methods employed to avoid a high concentration of outfitting work at any time within the compressed building schedule;
2. the types of automated equipment used in the pipe shop;
3. the role of apprentice school trained craftsmen in a largely automated pipe shop;
4. the extent to which standard subassemblies are fabricated in the shop;
5. the role of design documents in the fabrication activity;

### INSTALLATION

1. the methods employed to distribute outfitting efficiently over the entire building process;
2. the structural and outfitting tolerances required to ensure alignment of pre-outfitted structural block sections;
3. shipboard welding techniques.

## SECTION E.2

### PROPOSED FACILITY SURVEY

ITALCANTIERI S.p.A  
GENOA-SESTRI, ITALY

#### 2.1 BACKGROUND INFORMATION

Italcantieri, S.P.A, a part of Fincantieri (I.R.I. Group) was established in 1966 as a result of major reorganization in the Italian shipbuilding industry. Italcantieri is noted for its integration of the best design and technical capabilities available into each of its three shipyards - Monfalcone-(in Trieste), Genoa-Sestri (in Genoa), and Castellammare di Stabia (in Trieste). It also has relations-non a technical-operative level with-other yards of the Fincantieri group, which is the largest. shipbuilding and shiprepairing enterprise. in the Mediterranean area. Italcantieri also maintains a research center - Cetena (in Genoa), which develops advanced studies in shipbuilding for Italian as well as foreign companies.

The large size of the Fincantieri Group, which has eight construction and nine repair yards, allows the shipyards to be more specialized. In particular, Italcantieri is oriented to the construction of large series of ships, with each of its three yards concentrating on the construction of the types of ships which best suit its facilities. Although standard ship designs are emphasized, specialized designs can also be handled efficiently due to the great flexibility of Italcantieri's organizational structure. The Monfalcone Yard is geared for the construction of tankers up to 350,000 dwt in its graving dock, and the construction of other types of ships up to 140,000 dwt on its slipway. The Genoa-Sestri Yard builds ships up to 140,000 dwt in each of its three. graving docks. The Castellammare Yard builds ships up to 50,000 dwt on each of its two slipways. As of. January 1976, the following ships were under construction at these yards:

#### Monfalcone Yard (Trieste)

<u>Quantity</u>	<u>Type</u>	<u>Size</u>
5	Tanker (motor)	- 253,000 dwt
4	Tanker (turbine)	- 140,000 dwt

Genoa - Sestri Yard (Genoa)

<u>Quantity</u>	Type	<u>Size</u>
3	Container S-hip (turbine)	23,560 dwt
4	Bulk Carrier (turbine)	80,300 dwt
2	Bulk Carrier (motor)	80,500 dwt
1	Tanker (turbine)	139,000 dwt

Castellammare di Stabia Yard (Trieste)

<u>Quantity</u>	Type	<u>Size</u>
2	Product Carriers	30,100 dwt
6	Product Carriers	30,300 dwt

As can be seen from this data, Italcantieri is presently involved-in. the design and construction of a variety of ship. type and sizes. All three yards are reported to have excellent outfitting areas and straight-flow hull building lines. Transportation and processing sequences are largely automated and mechanized. Another important characteristic (which differentiates Italcantieri from most shipyards) is a design and drawing office which is one of the largest in Europe. Its establishment has allowed important progress to be made in general and detail design work, and there. have been considerable results in drawing, material, and working procedure standardization. Italicantieri's stated general policy is:

1. to employ advanced managerial techniques leading to more modern management;
2. to better the already highly qualified staff;
3. to employ design methods, able to reach-the best technical as well as economic results;
4. to employ working methods for the productivity of existing plants.

With respect to outfitting, advanced-organizational techniques are reported to be employed in order to increase production and to better productivity and the quality of the work. These techniques are:

1. execution of prefabrication of the hull along specialized lines;
2. extending the automation of machine working by means of modern- numerical control machines for oxy-cutting and working tubes;

3. employment of automatic welding machines:
4. adoption of the most technically advanced welding processes;
5. the increasingly advanced outfitting of prefabricated blocks, with extended standardization and **use** of packages;
6. recourse to the pre-erection of ships to obtain the earliest completion dates.

One of the most significant technical innovations at Italcanti is the use of IHI's unit assembly method of ship construction. at the Monfalcone and Castellamare Yards. Unit: assembling of fittings is a method by which a large variety of equipment and, fittings, including pipes and valves, is first assembled into units in the workshop or assembly yard and then installed in a ship under construction. It greatly improves working efficiency and consequently shortens the construction period of a ship, as compared with the usual outfitting method by which equipment and fittings are installed onboard singly piece by piece. Adoption of this method is said to improve working accuracy and safety in shipbuilding. This method was first developed by IHI some 16 years ago and has since been adopted for ship construction at all IHI shipyards, the shipbuilding process and workshop layout of which were especially rearranged for the purpose, with successful results.

Another significant technical innovation at Italcantieri is the recent acquisition of the IHI automated pipe processing system **and specialized pipe processing equipment manufactured by the German firm, Oxytechnik.** This sophisticated equipment provides for the completely automated processing of stock pipe and fittings into finished pipe sections ready for installation. Available information does not indicate whether or not IHI's Conversational Analyzer and Drafting System (CADS) has also been acquired to support the pipe handling system.

## 2.2 RATIONALE FOR MAKING ON-SITE SURVEY

The background information provided above indicates that an on-site survey of the Italcantieri Monfalcone yard should provide much valuable data related to the Task S-4, Advanced Pipe Technology project. In particular, it is anticipated that such a survey would provide information on the following specific items:

## DESIGN

1. the advanced methods of preparing design documents required to support the highly automated and diversified production facilities;
2. the extensive use of design and material standards in preparing design documents;
3. the methods of interference control used;
4. computer applications to piping design (IHI's CADS, if used);

## FABRICATION

1. the use of the design, documents during fabrication
2. the use of the IHI system of unit assembly with respect to outfitting;
3. the operational aspects of the IHI automated pipe handling system for diversified ship construction;
4. the operational aspects of the Oxytechnic equipment.

## INSTALLATION

1. the structural tolerances required to ensure accuracy in outfitting modular subassemblies;
2. the methods of production control required to ensure efficient outfitting of modular subassemblies on a flow-line basis.

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It should also be noted that because of Italcantieri's highly technically oriented organization and collaboration with IHI, their piping related technology is probably among the most advanced in the world.



## SECTION E.3

### PROPOSED FACILITY SURVEY HOWALDTSWERK-DEUTSCHE WERFT AG (HDW) KIEL, W. GERMANY

#### 3.1 BACKGROUND INFORMATION

All available information indicates that the Kiel Yard of HDW can definitely be categorized as one of the front running yards in Europe. They have been building ships of various types and sizes for 125 years. As of January, 1976, the following ships were under contract to be built by HDW:

<u>Quantity</u>		<u>Size</u>
1	Tanker (turbine)	138,850 dwt
4	Tanker (turbine)	239,800 dwt
1	<b>Product Carrier</b>	<b>136,000 dwt</b>
3	Bulk Carrier	36,000 dwt
2	LNG	67,000 dwt
1	Container Ship	40,000 dwt
3	Container Ship	11,600 dwt

HDW-Kiel is one of the largest shipbuilding yards on the European continent and appears to be growing in both capacity and efficiency. Their capacity has been considerably increased with the aid of extensive investments through which essentially all facilities have been modernized or upgraded and many new ones have been added. Among the many innovations in the pipe technology area is the acquisition of automated pipe flange welding equipment and a complete processing line for large pipes (which includes a cutting station, transport equipment, shape cutting machine, and pipe flange welding equipment). This specialized equipment is marketed by the German manufacturer, Oxytechnik.

Outfitting of the large tankers is currently approximately 70 percent complete at launch. Overboard outfitting and testing of the large tankers is carried out in this yard, where spacious berthst ample support equipment, cranes, etc. and outfitting shops are provided. HDW-Kiel appears to be heading in the direction of outfitting structural sub-assemblies making up the hull of the ship prior to erection. Deckhouses are almost completely Pre-outfitted now; including the finished joiner work, much electrical work. and all hardware items.

Intricate planning of outfitting in the machinery spaces is currently considered the most important factor in their outfitting planning program. They are using scale models extensively for this program. Information gained from the models allows design faults to be cleared before-the-fact. Color photographs are taken of the sectionalized model and each picture is dated, indicating scheduled completion of that block of work. Plans are to extend the current amount of outfitting being installed on sub-assemblies through use of the scale model planning concept.

Manpower appears to be a continuing problem at HDW-Kiel, much the same as with many U.S. Yards. This problem is being overcome to some extent through a program of recruiting and training foreign labor. However, HDW believes the real solution is comprehensive planning. On an unintegrated basis and organizing to get maximum performance from the manpower they have. To do this, they group work by area or section rather than by system and extend a single supervisor's responsibility and authority to accomplish functions within a specific area on schedule and within a firm budget. They are obviously making great strides in this direction, since they are turning out impressive tonnages of mixed products with relatively few people.

### 3.2 RATIONALE FOR MAKING ON-SITE SURVEY

Of the four yards selected for making on-site surveys, HDW-Kiel is currently building the greatest mix of ship types and sizes. Since most U.S. shipyards are also geared for the production of several ship types, it is anticipated that pipe technology methods studied at HDW would be most practical for domestic applications. In particular, the following items would be studied:

#### DESIGN

1. the use of scale model design techniques in a short lead time environment;
2. the types of design documents prepared for the fabrication and installation activities;
3. the use of design and material standards to facilitate mass production techniques;
4. the use of computers and special drafting techniques in design:

#### FABRICATION

1. the use of design documents in the fabrication process:

2. the types and capacities of automated pipe fabrication equipment;
3. the extent and methods of prefabrication;
4. the production control system used to handle the great variety of pipe types and sizes;

#### INSTALLATION

1. methods of maintaining efficient outfitting throughout the steel fabrication process;
2. structural tolerances required to ensure accurate fit-up of pre-outfitted subassemblies.

## SECTION E . 4

### PROPOSED FACILITY SURVEY ODENSE STEEL SHIPYARD, LTD. LINDO, DENMARK

#### 4.1 BACKGROUND INFORMATION

The Lindo Yard of Odense Steel Shipyard, Ltd. is one of the largest producers of tankers in Europe and one of the largest producers of ships from a single yard in the western world. As of January 1976, the following ships were under contract to be built at Lindo:

<u>Quantity</u>	<u>Type</u>	<u>Size</u>
	Supply Vessels	Unknown :
2'	Flat Top Barges	10,000 dwt
6	Bulk/Oil Carriers	65,000 dwt
5	Turbine Tankers	310,000 dwt
4	Turbine Tankers	330,000 dwt

The Lindo Yard is capable of building ships up to a size of 650,000 dwt. The older Odense Yard no longer produces complete ships but does supply the Lindo Yard with structural subassemblies.

Construction methods at the Lindo yard are reported to be among the most advanced in the world, and have resulted in production times for ULCC'S from keel laying to departure of 70-75 working days. The principal key in this accomplishment has been that while it has previously been normal shipbuilding practice to distinguish between steel work and outfitting work, Lindo has evolved a system which regards every part of the ship as an integrated unit consisting of both steel work and outfitting work.. This principle has determined not only the layout of the yard but also the methods of working. . High labor costs and a very tight labor situation have also contributed to the development of special production techniques. . It should be noted also that Odense has made considerable efforts to achieve the best possible labor relations at all levels, and that excellent training facilities are significant features of the whole Lindo operation.

Ship construction at Lindo differs from many other tanker building yards in that hull sections are produced on a longitudinal basis rather than transverse block sections. This technique naturally affects the methods of outfitting used. The basic concept for the Lindo yard has been the flow-line philosophy, coupled with much pre-outfitting. Outfitting is spread out over the entire building process and hence over the entire assembly area to meet the

requirements of pre-outfitting at the earliest possible time. small units consisting of only two or three outfitting components are first joined up to form larger machinery units and are finally united into heavy and complex platform and engine room units. A specialized shop is used for pre-outfitting of the engine room blocks. Application of this concept has made it possible to avoid or greatly reduce the unfavorable concentration of work during final outfitting, and, in turn, has made possible a considerable-reduction in total building time.

To support this system of construction, a numerical control system has been developed for pipe layout, which is used in conjunction with scale models. The Lindo Yard has made a specialty of scale--model techniques for main machinery and auxiliary machinery. -- disposition and has successfully developed, a numerical control program which, when used with the models, rapidly provides all the data required for the connecting pipework even as far as specifying. sizes and quantities required for this previously time-consuming and high complex work.

Machinery room layouts are extensively studied by means of the large color-coded models. Measurements from models become the input for Lindo's pipe sketch and control program, which is regarded as an important tool in cutting down outfitting time. Other spaces, such as boiler rooms and shaft alleys, are also portrayed in model form. Models are made to a scale of 1:20 and include equipment, ventilation, wireways, and piping down to one inch in diameter. The models are made by skilled personnel using system diagrams, machinery location plans, and design sketches: Piping system isometric plans are then made from the model. Models are also moved to the construction area for use by the foremen. Estimated cost for a set of models is approximately \$80,000, which Lindo feels is justified when more than two ships, of a class are to be built. For one or two ships, conventional design methods are apparently utilized.

#### 4.2. RATIONALE FOR PROPOSED ON-SITE SURVEY

Although Lindo utilizes basically the same flow-line concept as used by several European yards, such as Kockums, to produce similar types of ships, there are many techniques of the Lindo Yard which are rather unique in shipbuilding especially with respect to outfitting.- It is probable that many of these techniques. could be applied to U.S. shipbuilding and should therefore be covered in the Task S-4 study. In particular, it is anticipated that an on-site survey would yield information on the following items:

## DESIGN

1. the economic tradeoffs of using models versus more conventional methods of design;
2. the conditions required for efficient model production, such as lead time, and the types of documents required to produce the models;
3. the methods of preparing the models from the design documents and the level of accuracy maintained;
4. the types of design documents produced from models and how they are used for fabrication;
5. the extent to which material and design standards are used:

## F A B R I C A T I O N

1. the production control techniques used to integrate outfitting with the various stages of steel fabrication;
2. the use of the design documents and models during fabrication;
3. the types of pipe shop equipment utilized, and the level of automation required for the flow-line process;
4. the special fabrication techniques used to outfit structural subassemblies with a high degree of accuracy;

## INSTALLATION

1. the techniques used to ensure precise alignment of pre-outfitted systems during final fit-up of structural subassemblies in the building dock;
2. shipboard welding techniques.

SECTION E .5  
PIPING FABRICATION EQUIPMENT VENDORS  
(FOREIGN)

E.5.1 INTRODUCTION

The following paragraphs identify ~~four~~ major foreign vendors which are actively marketing some of the most advanced piping fabrication equipment in the world. Although only vendor data and a few trade publication articles were available on this equipment at the time of this writing, it is anticipated that on-site observation of some of this equipment during the proposed Task S-4 Foreign Facility Survey would provide additional information for evaluation by domestic shipbuilders.

E.5.2 MITSUI-AUTOMATED PIPE SHOP (MAPS) SYSTEM

The MAPS system represents an integrated approach to pipe fabrication. The numerically-controlled system automatically selects pipe from a storage ~~system~~, cuts the pipe to length and fits flanges, welds the flanges, and bends the pipe with flanges attached to the required design Configuration.

A detailed description of this ~~system~~ will be provided in the Final Report (Final Draft).

E.5.3 IHI PIPE PROCESSING SYSTEM

The IHI Pipe Processing System is almost identical to the MAPS system. The same flow process and types of equipment are utilized. The only major difference appears to be in the methods of making inputs to the system. IHI has developed a Computer Aided Drafting System (CADS) which greatly facilitates the design input process.

A detailed description of this system will be provided in the Final Report (Final Draft).

E.5.4 HICASS-P (HITACHI ZOSSEN'S COMPUTER-AIDED SHIPBUILDING SYSTEM - PIPING SUBSYSTEM)

The Hicass-P system is one of the subsystems of HICASS, an integrated data processing system developed by Hitachi Zosen for its own shipbuilding program. The subsystem can store in its data base all information concerning

ship piping, from preliminary design to production and installation stages, and provide as required useful data (including drawings and administrative information) for different stages of work.

A detailed description of this system will be provided in the Final Report (Final Draft).

#### E.5.5 OXYTECHNIK PIPING FABRICATION EQUIPMENT

Oxytechnik fabrication equipment is marketed by a German firm and is widely used throughout Western Europe. A listing of this equipment is provided on the following pages. A more detailed description will be provided in the Final Report (Final Draft).

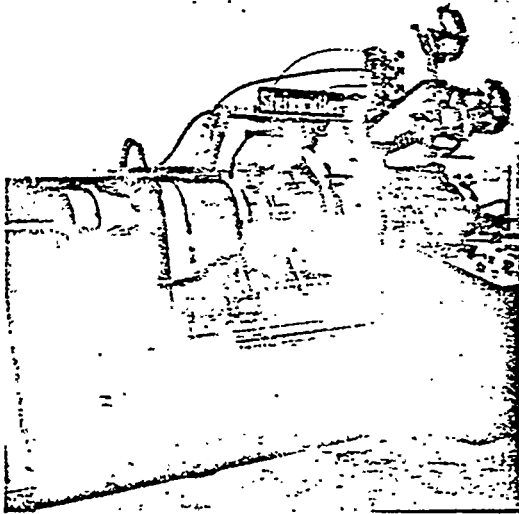


# REFERENZEN REFERENCES

Kunde Customer	Art der Einrichtung Type of Equipment
HOECHST AG, Ffm.-Höchst / BRD	2
MAN, Hamburg / BRD	1
STEINMÜLLER, Gummersbach / BRD	1
BAYER AG, Dormagen / BRD	2, 5
BAYER AG, Leverkusen / BRD	3, 5
Cantiere Navale Breda, Venedig / Italien	3
HDW, Kiel / BRD	4, 6
STORD-VERFT A/S, Stord / Norwegen	3, 5, 6
DUBIGEON-NORMANDIE S.A., Nantes / Frankreich	4, 5
ODENSE-Staalskibsvaerft, Odense / Dänemark	3, 6
KOCKUMS AB, Malmö / Schweden	3, 5, 6
ITALCANTIERI, Triest / Italien	3, 4, 5, 6
NOBISKRUG, Rendsburg / BRD	4
RHEINSTAHL NORDSEEWERKE THYSSEN AG, Emden / BRD	3, 4, 5

Kunde Customer	Art der Einrichtung Type of Equipment
RAUMA-REPOLA, Rauma \ Finnland	3, 5
GEBRUDER LUDIGE : MASCHINENBAU-GESELLSCHAFT MBH, Paderborn / BRD	7

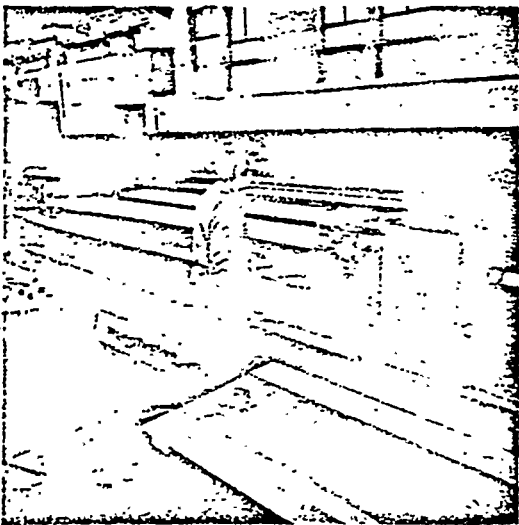
Art der Einrichtung  
Type of Equipment



1

Rohrstumpfschweißmaschine MIG/MAG- und WIG-Schweißprozeß

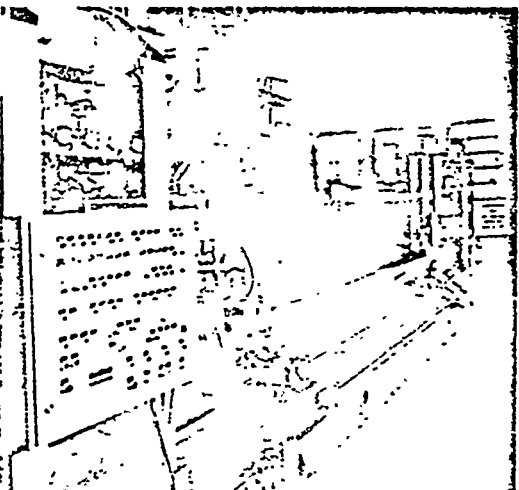
Butt joint welding of pipes, MIG/MAG- or TIG-welding process



2

Schweißmaschine zum Anschweißen von Vorschweißflanschen, MIG/MAG-WIG- oder PLASMA-Schweißprozeß

Neck weld flange welding machine, MIG/MAG-, TIG- or PLASMA-welding process

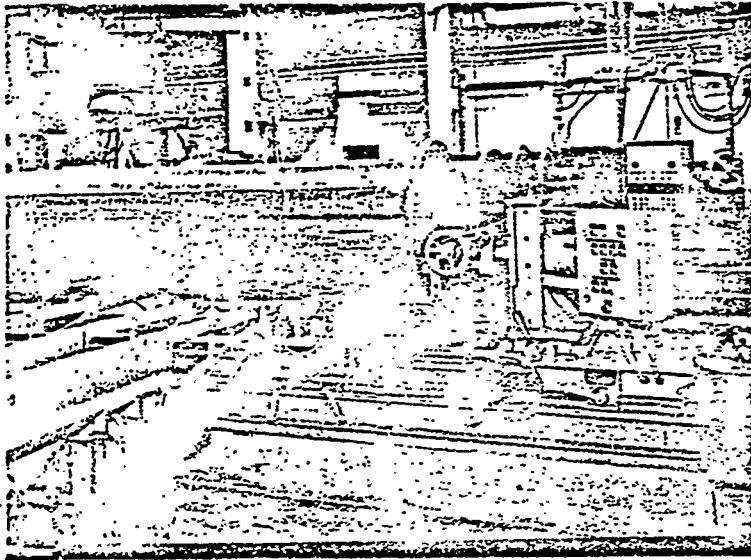


3

Rohrflanschschweißmaschine, NW 25 - 250 (max. 500) zum halb- oder vollautomatischen Anschweißen von Übersteckflanschen; Flanschzufuhr manuell oder maschinell

Pipe flange welding machine, NB 1" - 10" (max. 20"), slip-on flange, semi- and fully automated with or without automatic flange feeding

Art der Einrichtung  
Type of Equipment



4

Rohrflansschweißeinrichtung  
für alle Flanschttypen und Werk-  
stoffe, NW 40 - 800 mm.

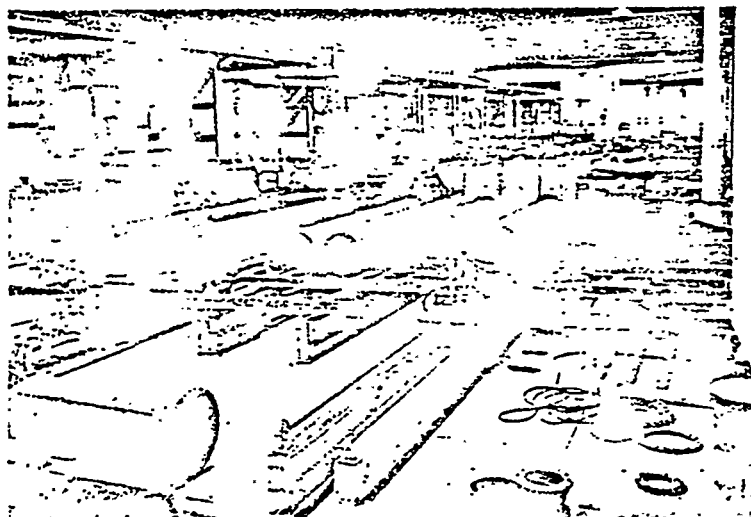
Pipe flange welding equipment  
for all types of flanges and  
materials, NB 1 3/4" - 32"



5

Komplettes Rohrverarbeitungs-  
system einschließlich z.B. Rohr-  
lager, Ablängstation, Transport-  
einrichtungen, Innen- und Außen-  
reinigung der Rohre, automatische  
Rohrflansschweißung etc., NW  
25 - 250 mm (max. 500)

Complete pipe processing system  
including i.e. pipe store,  
cutting station, transport equi-  
ment, internal and external  
cleaning, automatical pipe flange  
welding etc., NB 1" - 10" (max.  
20")

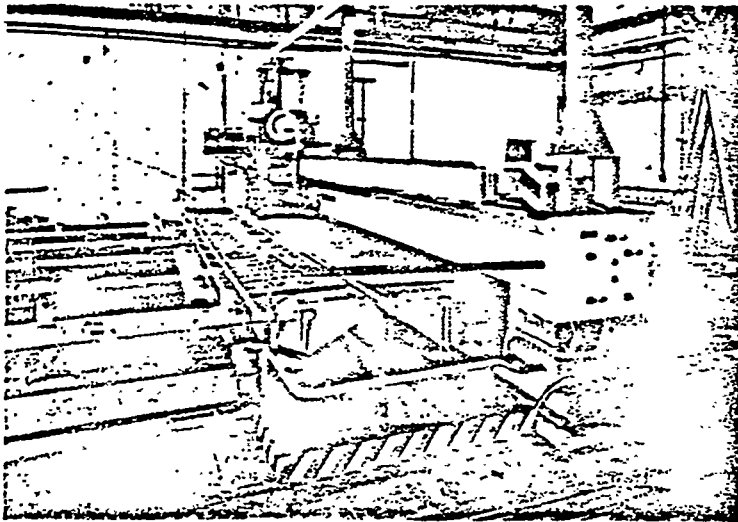


6

Großrohr-Verarbeitungslinie  
(z.B. Ablängstation, Transport-  
einrichtungen, Konturenbrenn-  
schneidmaschine, Rohrflansch-  
schweißeinrichtung)

Processing line for big pipes  
(i.e. cutting station, transport  
equipment, shape cutting machine)

Art der Einrichtung  
Type of Equipment



7

VACUSPANN-Einrichtung zum  
einseitigen Spannen von platten-  
förmigen Werkstücken mit UP-  
Schweißeinrichtung

VACUSPANN-equipment for one-side  
clamping of plates and submerged  
arc welding machine